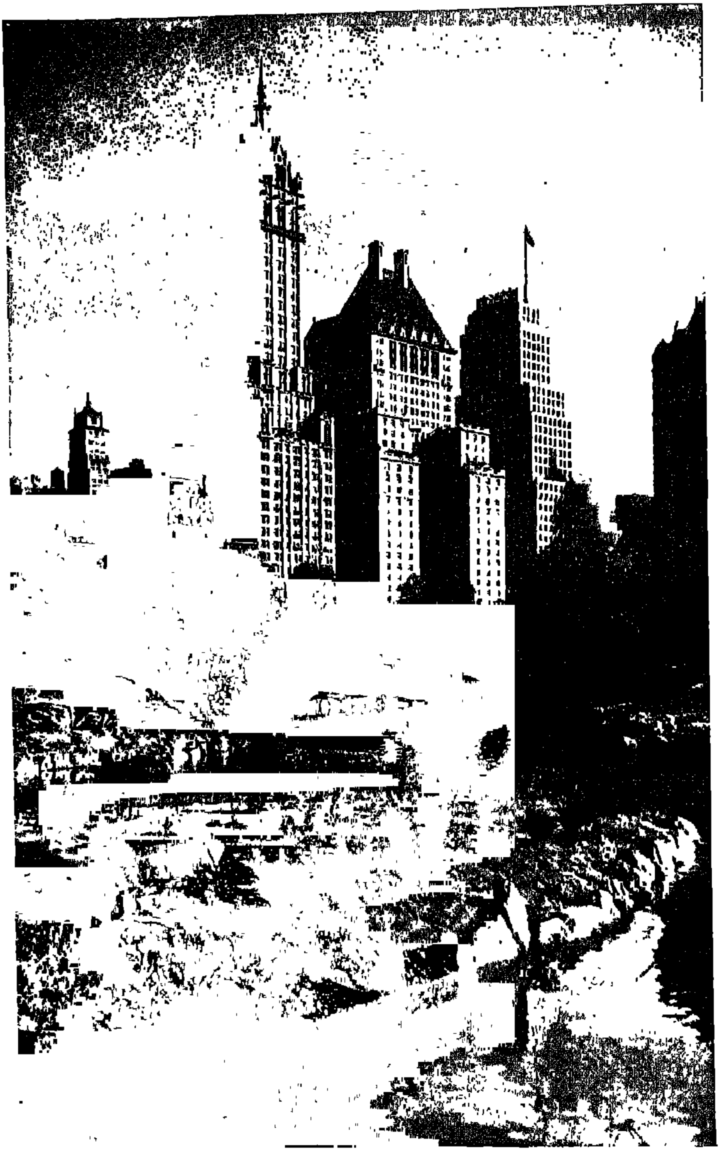

G. A. Douglas from Gendreau

People of today live in varied places, a few on the plains and in desert regions; more on the farm areas and many people crowd in cities. The people living and working in these three buildings would populate a small town.

THE MARCH OF SCIENCE

SCIENCE IN OUR SOCIAL LIFE

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SCIENCE IN OUR SOCIAL LIFE. H. & W

FOREWORD TO THE TEACHER

Education in a Changing World. Great changes in educational methods and objectives have recently taken place. The growth of the junior high school is an experiment in education brought about through a desire on the part of educators to integrate the work of the elementary school with the work of the high school. Into such a *school, the materials of science should be interwoven with* the curricular materials of geography, history, civics, and especially of health education. At the earlier levels the ultimate outcomes for the child should be the organization of the integrated knowledges in such a way as will make for some first-hand experiences with the factors of his environment and an understanding of the part played by such factors in his life activities; a desire to know more about and to help in the improvement of his environment, while at the highest grade level of the junior high school understanding, control and usage of the factors of the environment should be the ultimate aim.

To properly present learning elements in an integrated science curriculum at different grade levels, it is obvious that the mental age and especially the point of view of the pupil must be carefully considered. A terraced plan of attack must be used in which the capacities, interests, and science backgrounds of the seventh grade pupil must be considered as a distinct level in the development of the concepts treated in the course. Children grow much in capacity between the seventh and ninth grade levels. At the seventh grade level the teacher must use simple language. The science vocabulary should be restricted to the

use of relatively simple terms. The experiments and demonstrations should be easy to understand and to perform. The teaching techniques should be adjusted to the levels of the immature youngster of this group. At the eighth grade level, after a year of exposure to the junior high school activities, the boy or girl comes back to school in the fall with a perspective much enlarged and with a social viewpoint quite different from that held in the previous year. The instruction at this level and the quality of work will therefore be not only at a higher terrace of difficulty, but should be given from quite a different social viewpoint.

Classroom psychology and teaching procedures have shown that while the seventh grade pupil is rather an individualist, the same pupil at the eighth or ninth grade levels has a quite different outlook on school life. He has become a school citizen with the responsibilities of citizenship as a part of his mental outlook. It would seem very logical therefore to make our seventh grade science center on the individual and his personal reactions to his environment by integrating his science interests, leisure time activities, and health education material with the science concepts fundamental to an exploratory knowledge of his environment. On the other hand, as the ideals of citizenship and co-operation are developed at the eighth grade level, it would seem logical to make science concepts lead to a better understanding of such problems as are concerned with the purity of water supplies, the protection of food supplies, the control and prevention of disease in the community, and such other science topics which show the need for co-operative effort for environmental improvement on the part of school children. As the outlook of the child broadens in the third year of the junior high school, a third cycle of science activities will develop at a still higher terrace of difficulty. At this age level the child

might transfer his science interests to the wider field of the nation and the world.

The underlying theme for junior high school science should be first, at the lowest level, simple *knowledges* about the interesting and useful science in the immediate environment of the individual. In the second year *understanding* is more the goal, while in the last year *interpretation* and *application* of science are the desired outcomes. The philosophy of presentation should result in the ultimate generalization that man is the only one of all the animals who can control and artificially change his environment. As such, he has dominion over the earth.

Emphasis in science teaching is coming more and more to be placed on method, on problem solving, and the use of science facts in the solution of such simple problems as are within the comprehension of the pupils. Although generalizations and fundamental concepts are teachers' goals, they are not so evident to the pupils. Therefore, science courses must lead the child to see and later to understand the reasons for many simple demonstrations and experiments to the end that these understandings will lead to the goal of forming correct generalizations. Mature generalizations are not the immediate goal; it is the forming of these generalizations through science experiences gained through the usage of science materials that makes for the best teaching of science. Moreover these generalizations should be so mastered that they may be used by the student in explaining new science experiences with which he is continually coming in contact. Thus his knowledge is made usable and applicable. Science teaching will never function with the mere *learning* of *generalizations;* they must be used and *applied* intelligently in other science situations.

Our coming social group is bound to have more leisure time as the economic conditions in the future will doubtless

make for a substantially shorter working day and more and more time for avocations. The place of science in the junior high school points primarily to adjustment of the pupil to his environment so that he may best use these leisure hours. Science can do much for him in awakening interests and making hobbies worth while. Hobbies are important, both for young people and for older ones; collecting, fishing, hiking, keeping pets, gardening, anything that makes for intelligent interpretation and use of the environment.

This volume is the second of the series of texts which are organized about the child in this changing world of science as it relates to the scheme of things in his school and community. Here we have tried to integrate and correlate science with community civics and health education in the school and the community. We have taken advantage of the growing willingness for assumption of responsibility which is developing in the junior high school pupil at this level, and have centered the science around things relating to citizenship in the school and community.

Certain unique features in the series stand out. In the first place, the texts are written from the pupil viewpoint and great care has been taken to present the material so that it may fit the age level of the pupil. Concepts grow and what may be meaningful to the ninth grader could not be understood clearly by the seventh grader, therefore, a cyclic plan of treatment is used which is believed to be psychologically sound. Young people are interested in the science of the world around them, not in blocks of a given part of science. As Cox[1] so well says: "A child of the junior high school age lives in a world of things, forces, phenomena, and people. He does not live in a plant and animal world in the seventh year, and in a health world

[1] Cox, P. W. L., *The Junior High School Curriculum*, Scribner, 1929. By permission of the publishers.

his eighth year, and a physical science world his ninth year."

Emphasis throughout the series is placed on thinking rather than on the reproduction of facts. Factual material is necessary, but in this series of texts the factual material is used in a purposeful way to the end that simple science problems may be solved. These problems are fitted to the age level of the pupil so that even in the seventh grade he may become habituated in the methods used by the scientist. A conscious effort has been made to give the pupils reasons why the method of the scientist is useful in daily life to the end that a transfer of training may take place. Experimental work done by the students of one of the writers and other reported cases show clearly that if the child is made consciously aware of the value of the scientific method in his solutions of daily problems he will adopt this method and try to use it outside the classroom. Hence much emphasis has been placed in these texts on obtaining such attitudes on the part of the pupil.

The psychology of the unit with its social aspect is a force which makes for pupil interest and learning. The Morrison technique, with modifications which have been found desirable, is used throughout the series. Emphasis has been placed upon learning devices and a conscious attempt is made to show the pupil reasons for doing because of the desirable outcomes in transfer of training. Cuts, graphs, cartoons, and diagrams are made use of as learning devices. The Chinese were real thinkers, and their saying, "A picture is worth 10,000 words," showed real pedagogical insight. Throughout the text, questions are given as part of the legend under the cut so that the pupil will integrate the visual material of the picture with the printed word.

A very real attempt is made to fix associations by bring-

ing in related processes whenever possible so that the pupil realizes the relationships of one part of science with another. The psychological approach is used rather than the logical, as experimental evidence has shown this to give best results at this age level. While the value of the child's recognition of the big ideas and generalizations in science is seen, the greater importance of properly arriving at these generalizations has been stressed in this series. Numerous devices are used to this end: At the end of each preview the child is asked to think back to the work done in similar units at the seventh grade level, and a series of generalizations are suggested on which he will build the new concepts and generalizations at the eighth grade level. The review summary again presents a series of generalizations to which the pupil is asked to add. When this is done he is asked to place them in a proper sequence in his review summary outline. The practice in problem solving by means of the presentation of the textual material in problematic form, the various types of self-testing exercises, and the many thought questions at the ends of the units are examples of such aids. In addition, constant use is made of the motivation which comes through desirable activities such as those obtained by science clubs and excursions. Leisure time activities are also used as a means of stressing interest in learning science. These various activities are given relatively more emphasis at this grade level because of the opportunities afforded in this year of the junior high school.

ACKNOWLEDGMENTS

No writer in the field of the modern Junior High School could produce a series of texts without giving acknowledgments to the pioneers of curriculum making whose work has resulted in the evolution of the present-day curriculum. Among this host of names those of Barber, Bayles, Briggs, Carpenter, Charters, Cureton, Cox, Curtis, Frank, Harap, Pieper, and Powers stand out. Many other names might be mentioned, especially the groups who were responsible for the curriculum findings in the Twenty-sixth and Thirty-first Yearbooks of the National Society for the Study of Education. But in spite of their work, the subject matter included in the various courses of study that have been made (and there are hundreds of them) differs widely in scope and aim. But successful courses must be based on the findings of interest studies as well as successful practice of teachers who are practical and pragmatic in their philosophy of teaching.

The writers of this text frankly belong to this latter school, and the pages which follow are the results of practical work in the classroom, together with the acceptance of such findings in experimental teaching as best illustrate these objectives. It would be impossible to name all the teachers who have given help and inspiration to the writers, but the mention of the following must be made because of the personal contacts involved: Dr. Edna Bailey and Dr. Anita Layton of the University of California; Dr. Otis T. Caldwell of Columbia University; Prof. W. L. Eikenberry, State Teachers College, Trenton, N. J.; Miss Winifred Perry, Roosevelt Junior High

School, San Diego, Calif.; Dr. Frank M. Wheat, Head Department of Biology, George Washington High School, New York City; and Prof. Herbert E. Walter, Department of Zoology, Brown University, Providence, R. I. From each of the above, the writers have had help and inspiration.

The following have read the manuscripts either completely or in part and have given valuable constructive criticisms: Edith H. Bourne, the Fannie H. Smith Training School, Bridgeport, Connecticut; Francis R. Hunter, Assistant in Biology, Princeton University; George W. Hunter, III, Assistant Professor of Biology, Wesleyan University; Roy A. Knapp, Principal Antelope Valley Joint Union High School, Lancaster, California; and Frank M. Wheat, Chairman of Department of Biology, George Washington High School. In addition Dr. Wheat has added much to the teaching effectiveness of these books by his excellent diagrams and skillful cartoons. Wright Pierce has also added much to the text with his illuminating photographs. Dean Collins P. Bliss of the School of Engineering of New York University has offered much technical advice in certain parts of the texts, especially the problem on air conditioning. The Mississippi River Commission, the New Orleans Chamber of Commerce, the National Parks Service, the Bureau of Entomology of the U. S. Department of Agriculture, and others were helpful in their loans of material for illustrations. To all of the above are given the sincere thanks of the authors.

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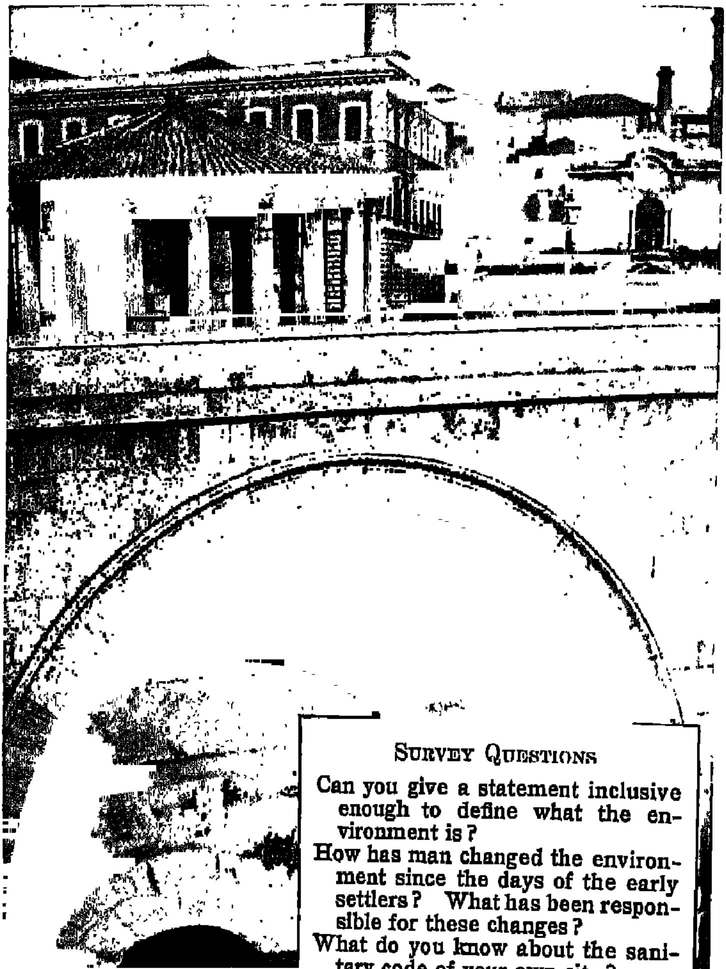


SURVEY QUESTIONS

Can you give a statement inclusive enough to define what the environment is?

How has man changed the environment since the days of the early settlers? What has been responsible for these changes?

What do you know about the sanitary code of your own city?

Do you know the story of how yellow fever was conquered?

What is meant by "the method of science"? Can you give an example?

Can the method of science be used in our daily life? Give an example of how you would do this.

Galloway

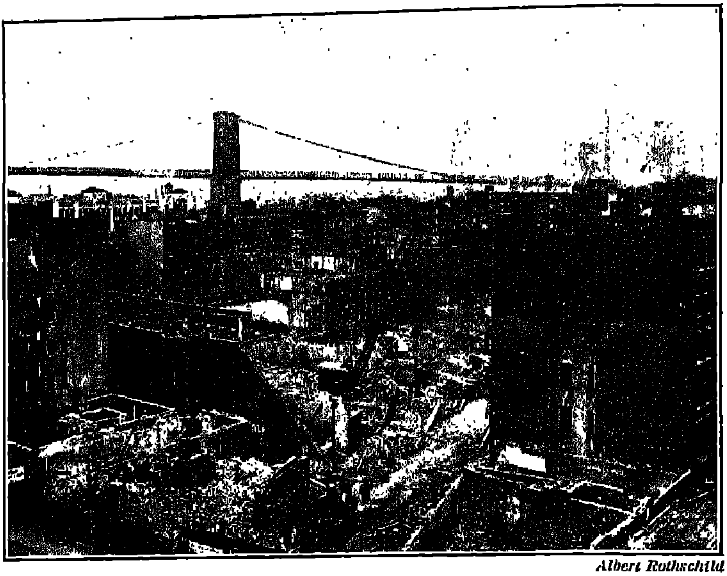
UNIT I

CONTROL AND IMPROVEMENT OF THE ENVIRONMENT

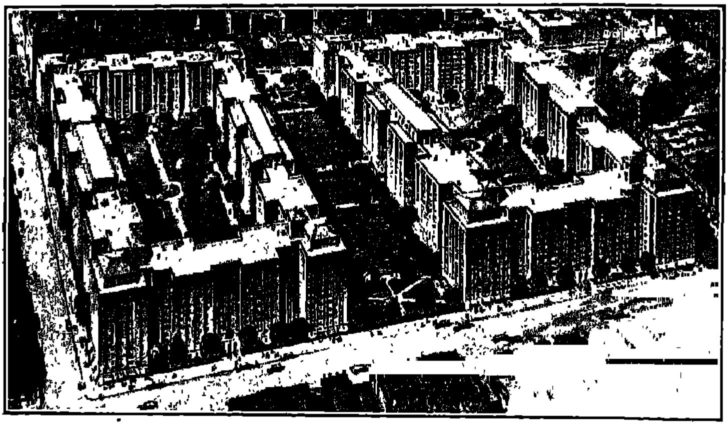
PREVIEW

Did you ever go by train from the country into a big city, such as New York or Chicago? Long before you reached the terminal, the train passed between blocks of buildings, large and small, until it seemed as if the city spread out for miles about the central station. And then once you are in the city streets, whether looking up at the tall buildings or watching the streams of traffic flow by, you cannot help thinking how different it is from the country which you left a few hours ago.

Man has certainly changed his environment in the making of a city. Rarely can we find the original soil, with its green grass and pleasant trees. Even the streams that once existed have been diverted into sewers, and the air once pure and clean has become choked with dust and smoke. Improvements have been made, of course, for we do have great buildings, paved streets, and pure water brought to the city from a clean source perhaps hundreds of miles away. The streets are cleaned and the wastes are disposed of either through sewers or by collection. The dust and smoke in many cities are eliminated, and even where dust and smoke are present the buildings may be air conditioned, thus removing these evils. Let us catalogue some of these changes which have resulted in safer and more comfortable living conditions. We have mentioned well-paved streets, pure water, and sewers to carry off wastes. But we have not mentioned such advantages as



Albert Rothschild



In many of our great cities housing conditions are being constantly improved. A few years ago this area on the lower east side of New York City was one of the most unhealthy in the city. Today the old tenements are being torn down and the beautiful buildings shown in the lower picture are being built. This is called "Knickerbocker Village." List all the improvements in living conditions found in the lower illustration.

mean? Later we shall see that green plants, when they make food with the power which comes from the sun, give off as a by-product the gas, oxygen. This gas is dissolved in the water and is used by the fish in breathing. Here it is evident that the environment was improved by adding the green plant to the aquarium.

How Man Improves His Environment. Take a trip with me into the densely populated area of a great city. A few years ago, when our housing laws were not as strict as they are today, such areas would be filled with people, crowded together in homes where light and air were deficient. In the slum districts of great cities no trees and grass were to be found. There were not even small parks or playgrounds where boys and girls could play. The tall tenement houses were built close together with little regard for light or ventilation. Often such dwellings would contain rooms without a single window, and such rooms were used as bedrooms by entire families. No wonder that diseases such as tuberculosis and other respiratory troubles were common, and that the death rate in these areas was much higher than in other parts of the city. Such slum areas are not so numerous today. Why is this? First, because laws have been made to protect poor people who are forced by circumstances to live in unfavorable environments; and secondly, because we are all becoming educated to the fact that we can improve our environment and thus keep people in better health even when they are forced to live in crowded city areas. It pays to spend public funds and private fortunes to improve and lengthen life, and that is what we are beginning to see today. Health is a civic obligation.

Some Problems Which Come from Our Living Together. The Indian Uncas would probably have thought that the artificial environment we find in our cities today was not as good as the forest and stream of his natural

environment. In a way he would be right, for man cannot improve much on nature. Wherever people have come to live together in large groups, new problems have

Are you doing your share to offset the selfishness of these people?

arisen. People are selfish and too often think only about themselves and their families, and little about the rights of others who live near them. Consequently there arose problems of keeping the water supply pure and uncontaminated from the other person's wastes; the problem of having pure air, unsullied with dust and smoke; and the problem of disposing of garbage and ashes, wastes that would soon make a community unsightly and insanitary. The roving Indian had none of these problems to meet and we know that later, when man brought to

him some of the evils of civilization, he failed to meet the problem of living successfully.

Why Some People Do Not Co-operate. Evidently much of the selfishness of people living in communities is due to lack of education along the lines of sanitary science. People ought to know that germs exist almost everywhere, and that by carelessness they can scatter them in air, food, and water. If there is a case of illness caused by bacteria in their own home, they ought to know that, unless they are careful, they may pass on to others the germs that cause disease. They ought to think of the rights of their neighbors to have quiet and rest. They ought to know that every insanitary act they commit may affect somebody else. But while you are able to learn how to do your share in keeping your community healthy and clean, there are many who have never had this opportunity.

Why We Have a Health Department. For such people, as well as those who are criminally negligent, the community must have laws and means of enforcing them. It must have a department of health which will not only report cases of contagious disease, enforce quarantine laws, and counteract disease by modern methods, but there must also be regulations to prevent the sale of impure foods. A modern community must have hospitals, clinics, and sanitariums provided for its citizens, as well as schools, parks, and playgrounds.

How You Can Help. There are many ways in which boys and girls can help make their community a better place. Start in the school. Organize clubs or squads which will help keep the school grounds clean and attractive. Have traffic squads to take charge of the street crossings near the school. Organize your science club to make a sanitary survey of your part of the city. Get copies of the sanitary code from your health department

and report all violations to the proper authorities. Visit the health department and see what its organization is. Know what public buildings you have and their uses.

A. Tennyson Beals

Most city schools have playgrounds, which can be used on holidays as well as during school hours. Why is this a wise arrangement?

Find out where and how the community gets its water, and how it disposes of sewage and wastes. In other words, learn to apply your science in citizenship so that when you become a voter and taxpayer, you can vote intelligently and make your community a better place to live in.

SELF-TESTING EXERCISE

Select from the following list those words which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

size	population	health	oxygen
vote	area	houses	new
selfish	unlimited	disease	crowded
co-operate	science	superstition	artificially
reasons	environment	water	responsibilities
wealth	want	laws	nitrogen

Green plants by giving out (1)____ improve the (2)____ of fish in (3)____. Because of stricter housing (4)____ there is less (5)____ in (6)____ sections of cities than formerly. As population in a limited (7)____ increases, (8)____ problems arise. People are (9)____ and many are not educated to understand the (10)____ for their (11)____ as citizens. By applying (12)____ to everyday needs, man has improved his artificial (13)____ and made it a more desirable place in which to live. Each school member should try to (14)____ with authorities and to know the (15)____ problems of his city so that when he becomes of age, he can (16)____ intelligently.

ESSAY TEST

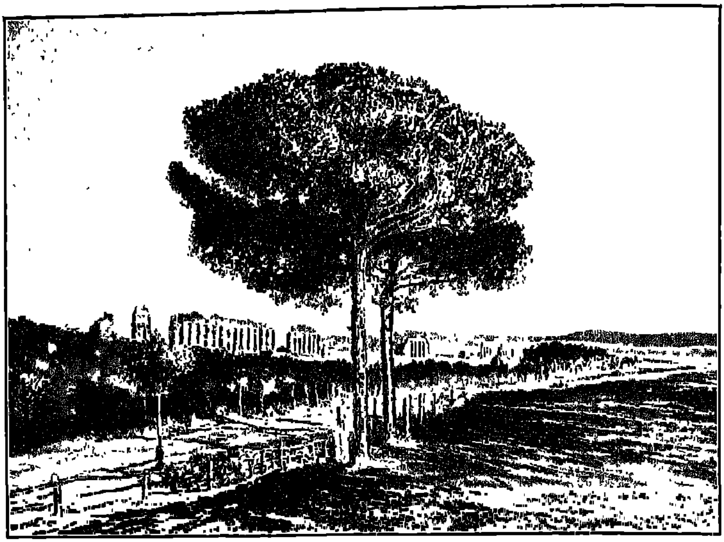
CARL TELLS WHY HIS ENVIRONMENT SHOULD BE IMPROVED

Read carefully and critically. List all the errors and suggest corrections.

I happen to live in one of those parts of our city which we call a slum. I can tell you some reasons why that district ought to be improved. In the first place, the streets are narrow and the buildings old and built close together. The rooms in our apartment are small and the windows are all on a court so we do not get much light and no air. There are lots of people who have colds and coughs. I guess it is because they have so little sun in their rooms. Then the streets in my district are hardly ever cleaned and when they do clean them, the sweepers raise such a dust that you can hardly breathe. Even the trees have died in our neighborhood. Perhaps they never planted any. I tried to keep a green plant in our living room, for somebody told me they purified the air, but the plant would not live. I guess it did not have enough air. Certainly the people who live in our neighborhood need education too, for they throw garbage out of the windows and down into the courtyard, and the street is littered with refuse and papers. We certainly need a new deal down there.

PROBLEM II. HOW ENVIRONMENTS ARE IMPROVED

How the Romans Improved Their Environment. No one who has visited Italy and has seen the ruins of the Old Roman aqueducts and public baths can forget the part water must have played in the lives of the Romans. In spite of the fact that they knew nothing about germs and their dangers, they did know that it was worth while



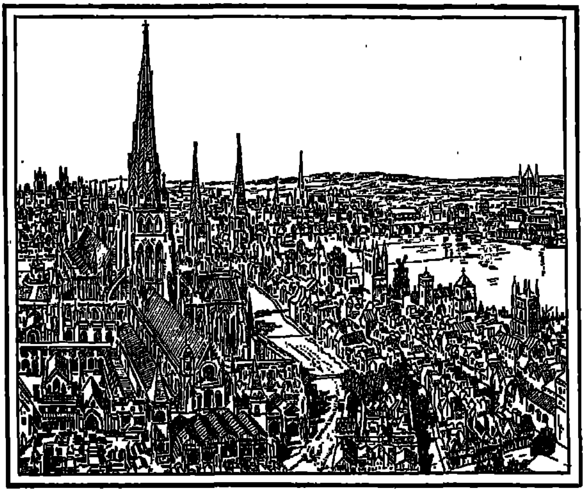
The ruins of Claudian Aqueduct. It was completed about 50 A.D. and brought water 44 miles from mountain springs. Ancient Rome had nine of these aqueducts, the first built 312 B.C. Why did they go to the hills for water?

to have a plentiful and pure water supply. So that shortly after the birth of Christ their engineers had planned great and costly aqueducts to bring pure water down from the mountain springs in the Sabine hills 44 miles north of Rome, and built them so well that these ruins exist today. But even 300 years before this the Romans had an excellent water supply. If one looks across the Tiber toward the old Roman Forum, he will see a huge opening with a brick wall, the mouth of the Cloaca Maxima, or great sewer that drained the market places and streets of old Rome. This sewer, probably built in the second century A.D., has been in constant use until very recent times.

Health and Wealth Did Not Go Together in Olden Times. On the other hand, if we could have lived in London in the golden age of England at the time of Queen

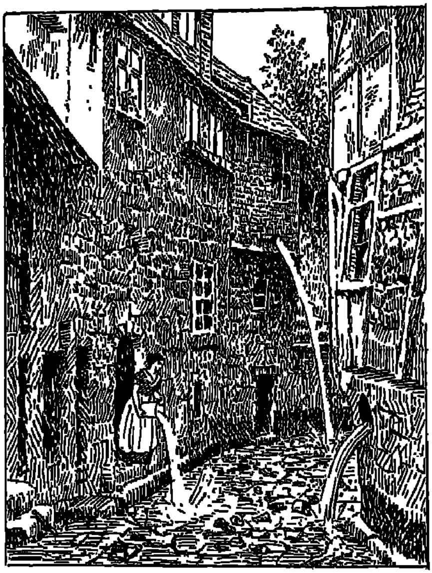
Elizabeth, we would have been shocked and offended at the lack of sanitation. Drinking water was taken from wells polluted by sewage; the streets were open drains, into which wastes and filth were thrown; and while the homes were well built and the windows were filled with small panes of glass, instead of being covered with glazed paper or heavy wooden shutters as they were in earlier times, the toilet and heating arrangements were of the most primitive sort. Homes had "beautiful carved oak furniture, rich embroideries, glazed windows, and panelled rooms" but they were wastefully heated by great open fireplaces and had no bathrooms.

The Dark Ages and After. While the Romans knew a good deal about sanitation, we find that many of the discoveries and usages of the Roman civilization were forgotten or discarded during the dark ages. What science there was gave place to superstition. People were disgustingly dirty. Bathing was uncommon; vermin swarmed everywhere; sewage ran into the streets and



London at the time of Queen Elizabeth. Compare the homes of the people with the churches and palaces.

polluted the drinking water; refuse from the table was left where it was thrown. So it was that this period became a time of pestilence and famine. The improvement of crops and cattle, of garden vegetables and poultry, and all the other food sources of the nations did not keep pace with the luxury in the homes of the wealthy, with the result that many went hungry, for there was not enough food for all. And even in the Elizabethan era little attention was paid to sanitation and community hygiene, with the result that great epidemics swept the country, as we know from a reading of Pepys' diary of the great plague year when over 150,000 Londoners perished of bubonic plague.



In what respects is a modern city an improvement over the conditions shown here?

Yellow Fever and Malaria. But we do not have to go back to the dark ages to find epidemics, nor to see how, by improving the environment, a deadly disease could be stamped out. It is an old story now, the story of how Havana was rid of yellow fever. But it is such a tale of heroism and scientific discovery that it is worth telling again. It does not seem possible that until recent years two insects, the *Aëdes* mosquito which causes yellow fever and the *Anopheles* mosquito which causes malaria,

WALTER REED, 1851-1902.

BORN in Virginia, Walter Reed got his education in the University of Virginia and as an interne in Bellevue Hospital in New York City. Later, as a young army surgeon, he studied bacteriology under the then famous Professor Welch of Johns Hopkins. In 1893 he was placed in charge of the Army Medical Museum in Washington and had it not been for our war with Spain, he doubtless would have remained at that post. But with the outbreaks of fever which followed our army in Cuba, he was appointed head of a Commission to investigate the cause and control of yellow fever. You all know the story of the experiments in which Dr. Lazear died and several brave volunteers nearly lost their lives. The discovery that the yellow fever was carried by the Aëdes mosquito was proven and Havana was without yellow fever for the first time in two hundred years.

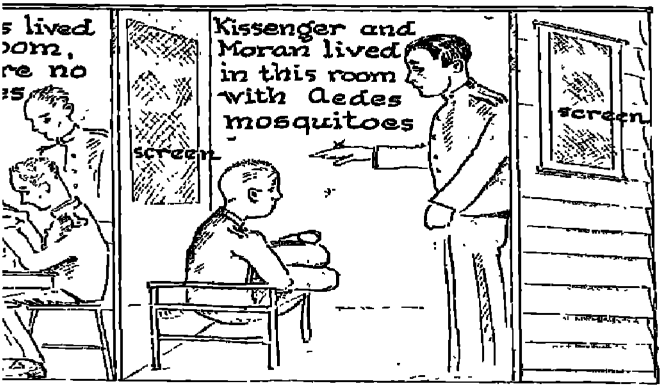
Walter Reed did not live long after his great work, for he died of appendicitis in 1902. Today one of the largest army hospitals in the United States is named after him.

had been responsible for about two million deaths every year.

The Work of the Army Commission. During the Spanish-American War, the United States army suffered more from malaria and yellow fever than it did from enemy bullets. So after the close of the war in 1900, a medical commission was appointed by the President to study the cause of yellow fever. This commission, with Dr. Walter Reed at its head, soon began experimental work.

At first some members of the commission thought that the fever was transmitted by soiled bedding or clothing used by yellow fever victims, while others believed that it was transmitted by the bite of a silvery gray mosquito, called *Aëdes*. Dr. Jesse Lazear, who was one of those who believed in the mosquito theory, allowed himself to be bitten by such a mosquito which went to him directly from a yellow fever patient; he died of yellow fever shortly afterwards. This looked like sure evidence, but scientists want their experiments controlled, and so the commission asked for volunteers who would be willing to submit to experiments that might give them yellow fever. Money was offered to those who would be willing to expose themselves to what might mean death. But two of the volunteers, army privates named Kissenger and Moran, stipulated that they would offer their services without pay and solely in the service of science. Dr. Reed is said to have drawn himself up, touched his cap, and said, "Gentlemen, I salute you."

Some of the Experiments. Several experiments followed. In one several soldiers slept and lived in a screened room in which the dirty furnishings and bedding used by yellow fever victims were placed. The men even slept in pajamas worn by men who had died from yellow fever shortly before. But after twenty days of



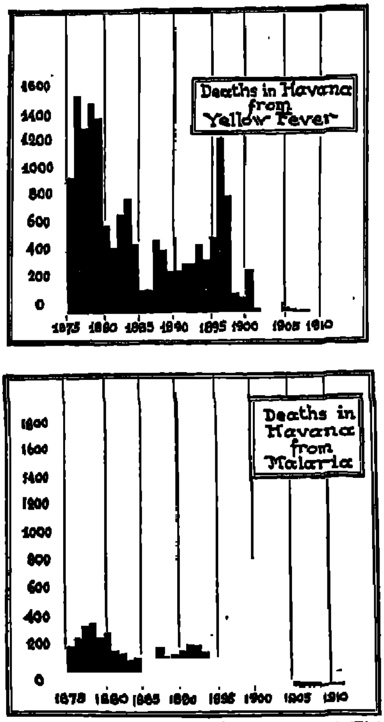
and then tell what happened in this experiment.

men were free from yellow fever. They d to contact with the disease, but had by mosquitoes.

riment was tried. A long room well-tected from mosquitoes was divided by e side lived several soldiers, while on the placed Kissenger and Moran. These rotected by screens, but on their side of introduced *Aëdes* mosquitoes that had ver patients. Both of these men came w fever. In this experiment the control et yellow fever, while the two men who get it, thus proving without doubt that uito was responsible for spreading the

Conquered through Control of the En- s interesting to know that the cause of never been found in spite of the work ts. Some of them, like Dr. Noguchi of nstitute, have given their lives as sacrifice But in spite of the fact that the cause is ellow fever has been practically stamped

out through the extermination of the *Aëdes* mosquito in most places where it was once a serious menace. The breeding places have been oiled so that the young cannot hatch out, or swamps and ponds have been drained, homes screened, and everything possible done to eradicate the pest. Look, for example, at the city of Havana — a few years ago a place shunned because of its malaria and yellow fever. Today it is a health resort visited yearly by thousands of tourists.



Am. Mus. of Nat. Hist.

The control of yellow fever and malaria in Havana has made possible the development of the island as a great vacation resort.

How the Scientist Works. This shows how the method of science was used in the solution of a problem in which the saving of human lives was the goal. The steps of the experiment we record as follows: (1) the determination of the question or problem to be solved; (2) the various methods devised for the attempted solution of the problem; (3) the observations made, tabulated, and compared in the attempt to reach the conclusion; (4) the testing or verification of the tentative conclusion reached as a result of the experiments made; and finally (5) the application of the principles sought in the experiment. These steps are seen if we compare the story with

the outline just given. The first step is seen in the outlining of the problem by the commission with the underlying thought that mosquitoes had something to do with yellow fever. The second step is seen in the various experiments tried, one of which resulted in the death of Dr. Lazear. The third step, made by the many workers, brought together a mass of material that pointed to the mosquito as the guilty party. The experiments with Kissenger and others verified the tentative conclusions reached, and the final step or application came with the clean-up of the breeding places of mosquitoes, the screening of houses, and the consequent drop in the death rate as shown in the chart on page 16.

The Results of Scientific Improvement of the Environment. Today life is very different from what it was in the middle ages or even 100 years ago. Science has shown people that plant and animal resources can be improved and increased in numbers through the use of fertilizers, irrigation, and plant and animal breeding. Through the use of machines and the harnessing of power, work is done so as to give us much more leisure than we have had

Galloway

What advantages has a swimming pool over the ocean? What disadvantages might it have?

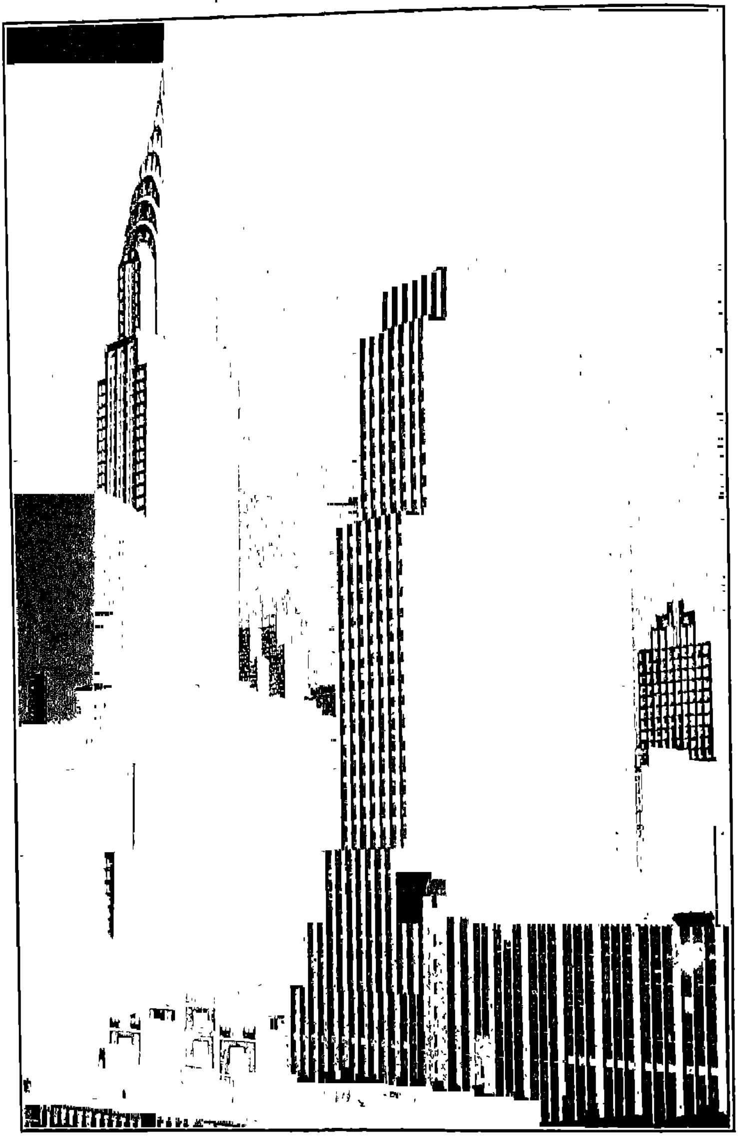


Photo by Geo. A Douglas, R. I. Nesmith

Modern New York office buildings showing " set backs." Why is such construction necessary in a crowded city?

in the past. Consequently we are beginning to find new ways to use this leisure. Communities are creating new playgrounds, stadiums, and parks; states are putting reservations where people may hike, fish, and camp. In regions where natural beauty of scenery exists, new national monuments and parks are being opened. Since science has perfected the automobile, hundreds of thousands of people visit these places every year seeking enjoyment, while cheap and easy transportation between city and country is made possible through its use.

In cities science has created new types of buildings, safe, well-lighted, and practical as well as beautiful. While skyscrapers have changed city streets, laws have caused high buildings to be set back as they go higher into the air, thus assuring light and ventilation. Science has created easy ways of getting up and down in these buildings, has bountifully supplied them with water and heat, has introduced smoke-consuming devices which keep the air clean, and in many other ways has made the city a safe place to live in. Radio has come to amuse and interest people, giving them good music, fun, or news of world affairs as they please. Through good roads, the automobile, radio, better schools, and health service, the country dweller has equal chances with those who live in the city. Communities and nations are beginning more and more to realize that public health is a very big asset, and that a city is losing out in competition with other places if it does not care for the health of its citizens. Altogether science has done much and will do still more to improve the environment in the future.

SELF-TESTING EXERCISE

Select from the following list those words which best fill the blank spaces below and arrange them in proper numerical order. A word may be used more than once.

unsanitary	control	breed	epidemics
commission	3000	2000	safe
sewers	unsafe	cause	aqueducts
yellow	pure	*Aëdes*	change
sanitary	*Anopheles*	science	1000
carried	1900	middle	1800

Over (1)____ years ago the Romans had built costly (2)____ to bring (3)____ water to Rome, and had built (4)____ as well to carry off wastes. But in the (5)____ ages people were not so (6)____ and as a consequence great (7)____ of plague and other diseases occurred. Even as late as (8)____ malaria and (9)____ fever claimed thousands of victims every year and made many parts of the world (10)____ to live in. But (11)____ has changed all this today. The Reed (12)____ discovered that yellow fever was (13)____ by a certain mosquito called (14)____, and although the (15)____ of the disease is not surely known today, this disease along with malaria has been almost stamped out through (16)____ and (17)____ of the environment where mosquitoes (18)____.

ESSAY TEST

Alice Writes about the Changes in the Environment Brought About by Science

Read carefully and critically. List all the errors and suggest corrections.

I don't believe anyone living in the times of Greece and Rome would recognize the world today as a place he lived in. Things are so very different. In the first place they didn't have any big cities, for Athens and Rome were only villages. Then, their buildings were low and not very beautiful. The streets were not paved and they had no water supplies, no water in the buildings, no sewers, no street lights, and no parks or playgrounds.. They knew little about the use of machines and less about modern lighting and electric power. And of course they had no knowledge of medicine or sanitation. The Romans were no better off than Europe in the dark ages, for they had little or no knowledge of the applications of science. But today all has changed. Science has remade the world and its life by changing conditions so that disease cannot exist.

THE REVIEW SUMMARY

In preparing a summary of what you have found out in this unit, you will want to place emphasis on the big ideas which have come from the applications of the facts you have learned and the demonstrations you have seen. Doubtless you have done some additional reading which has helped you put together some of the facts into generalizations or fundamental underlying principles. For this unit these generalizations are:

1. Some environments need to be improved because of the artificial conditions brought about by many people living together.
2. People are thoughtless and selfish, so laws have to be made to protect others from the results of their heedlessness.
3. Some diseases can be wiped out through changes in the environment.
4. Science has made life safer and more comfortable through its many discoveries.

Before making your review summary for your workbook, test your knowledge of the facts of the unit by checking over the text so as to be sure you know the facts underlying the science principles or generalizations. Then using this material and everything you have read, seen, or done yourself, make your summary outline. This outline you may use when you make a recitation.

TEST ON FUNDAMENTAL CONCEPTS

In a vertical column under the heading CORRECT *write numbers of all statements you believe are true. In another column under* INCORRECT *write numbers of the false statements. Your grade = right answers × 3⅓.*

I. **Green water weeds are a necessary factor of the environment for goldfish because:** (1) they make a restful place to live in; (2) they are good for the fish to eat; (3) when the sun shines, they give off oxygen to the water; (4) they look well in the aquarium.

II. **Man has changed his natural environment by:** (5) building cities; (6) building railroads and highways; (7) adding new factors to it; (8) making use of natural forces to do his work.

III. **Man needs to improve his environment:** (9) when overcrowding results from slum conditions; (10) when his water supply is not pure; (11) where natural conditions have been replaced by artificial conditions; (12) where individuals are careless of the rights of others.

IV. **The Romans had considerable knowledge of sanitation as is proved by the fact that:** (13) their temples were beautiful specimens of architecture; (14) they had a sewer which drained the Forum; (15) they got their water from pure mountain springs; (16) they enjoyed bathing in public baths.

V. **Health and wealth did not go together in medieval times because:** (17) the better homes did not have proper sanitation; (18) people both rich and poor had dirty and slovenly habits; (19) drinking water of the rich was often polluted; (20) there was not food enough to go around.

VI. **Yellow fever:** (21) is caused by a mosquito; (22) is carried by the *Aëdes* mosquito; (23) caused more deaths than bubonic plague prior to 1900; (24) was virtually stamped out in Cuba through the work of the Yellow Fever Commission.

VII. **Science improved the environment:** (25) when it showed that by draining swamps mosquitoes could be destroyed; (26) when man put up advertising signs along highways; (27) when old buildings in slums were torn down to be replaced by sanitary dwellings and playgrounds; (28) when hospitals and schools were built.

PRACTICAL PROBLEMS

1. In what ways has man improved your local environment, and in what ways was it probably better before man came into it? Make two columns and see how they look after you have put everything down.

2. Suppose you had lived in your locality at the time the Indians did, how would you have met your problems of living?

3. Why was it that during the middle ages sanitary conditions were so much worse than in the time of the Romans?

4. Compare the sanitary conditions in a city in the interior of China today with a city in this country. Ask someone who has lived in China to give you some facts on the disposal of human wastes in that country.

5. How many science discoveries do you know that have actually helped to improve your environment?

6. Apply the saying: "An ounce of prevention is worth a pound of cure," to community sanitation and health problems.

7. The following oath was required for citizenship in ancient Athens before a man became a citizen of that democracy:

"We will never bring disgrace to this, our city, by any act of dishonesty or cowardice, nor ever desert our suffering comrades in the ranks.

"We will fight for the ideals and sacred things of the city, both alone and with many.

"We will revere and obey the city's laws and do our best to incite a like respect and reverence for those in authority, who are prone to annul or to set them at naught.

"We will strive unceasingly to quicken the public's sense of civic duty.

"Thus in all these ways we will transmit this city not only not less, but greater, better, and more beautiful than it was transmitted to us."

How would you modify it for use in your school or city?

INTERESTING THINGS TO DO, READ ABOUT, OR SEE

1. Look up the story of yellow fever in Paul De Kruif's *Microbe Hunters*, and report to the class on it.
2. Make a health poster for the bulletin board to illustrate some phase of the work of this unit.
3. Make an original health slogan and submit it to the science club for exhibition.
4. Find out from some public health office when there will be a broadcast of health talks by your state department of health.
5. Make a collection of clippings bearing on improvement of the environment.

SCIENCE FOR LEISURE TIME

1. Read for pleasure some of the following books:

Beebe, William, *The Arcturus Adventure.*
Cooper, J. F., *The Last of the Mohicans.*
Darrow, F. W., *Thinkers and Doers.*
De Kruif, P., *The Microbe Hunters.*
De Kruif, P., *Seven Iron Men.*
Grenfell, W. F., *A Labrador Doctor.*
Kelley, H. A., *Walter Reed and Yellow Fever.*
Van Loon, H. W., *The Story of Mankind.*
Williams, Ellis, *Men Who Found Out.*

2. Make a relief map of your community and its vicinity. Then try to find out from the city engineer where the sewers and water pipes are located.
3. Make an excursion to the source of your local water supply and report to the class what you saw.
4. Prepare for your own workbook a collection of pictures cut from magazines or old college and school catalogues showing the educational institutions in your state or county.
5. Make photographs of the best and worst places you can find in your town and exhibit them on the bulletin board.

SCIENCE CLUB ACTIVITIES

1. Work with other members of the school and the faculty to organize a health committee, the function of which is shown in the

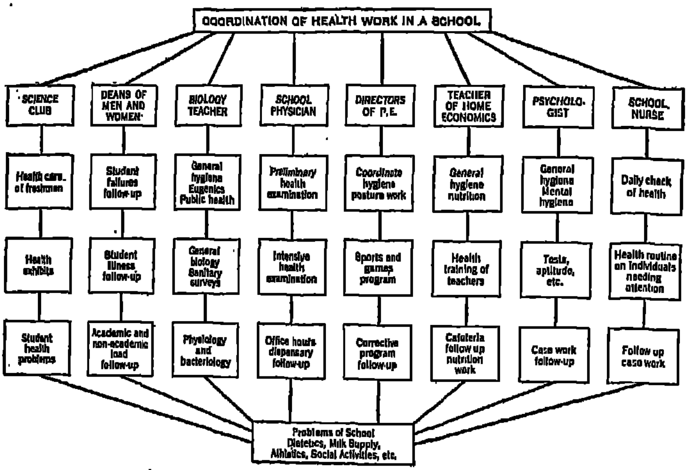


diagram above. If you can get this plan started early in the school year, you may be able to do something of great value for your school.

2. Appoint a Junior Health Council and plan for a series of meetings on "How we may help improve the environment."

3. Plan for publicity about these meetings in the school and the local papers.

4. Arrange to have the local health officer or an interesting doctor speak at assembly on some of the health problems.

5. Organize a committee for each room whose duties will be to hold morning inspection and report to the Senior Health Committee, which is composed of teachers, on exclusion from school of all children who show signs of contagious disease or who seem ill.

6. Organize a sanitary squad to take over the supervision of the lunch room and school grounds at lunch time.

7. Plan a survey of your local environment. Allot the different parts of the community to different boys and girls who live near or in these areas. Make your report to contain information about the location of playgrounds, parks, swimming pools, churches, public libraries, schools, and other public buildings. Note by some insignia all insanitary buildings, outdoor toilets, all garbage or refuse heaps, dumps, or any other places that are insanitary.

8. Plan a similar survey of the school building and school grounds. Point out conditions that need improvement, and make suggestions for their improvement.

9. Make a survey of the local mosquito problem. What kind of mosquitoes are found in your neighborhood, and at what season are they bothersome? What state or local work has been done to control them?

10. Appoint a Bulletin Board Committee to take charge of a poster exhibition.

11. Plan a bulletin board exhibit of health slogans and offer a prize for the best.

12. Plan a sanitary and health code for your school.

REFERENCE READING

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De Kruif, Paul, *Men Against Death*, Harcourt, Brace, 1932.

Finch, C. E., *Guideposts to Citizenship.* American Book Co., 1927. Chapters V, IX, XIX.

Hunter, G. W., and Whitman, W. G., *Civic Science in the Community.* American Book Co., 1922. Chapters I, IX, X, XV, XVIII.

Ritchie, J. W., *Primer of Sanitation.* World Book, 1925.

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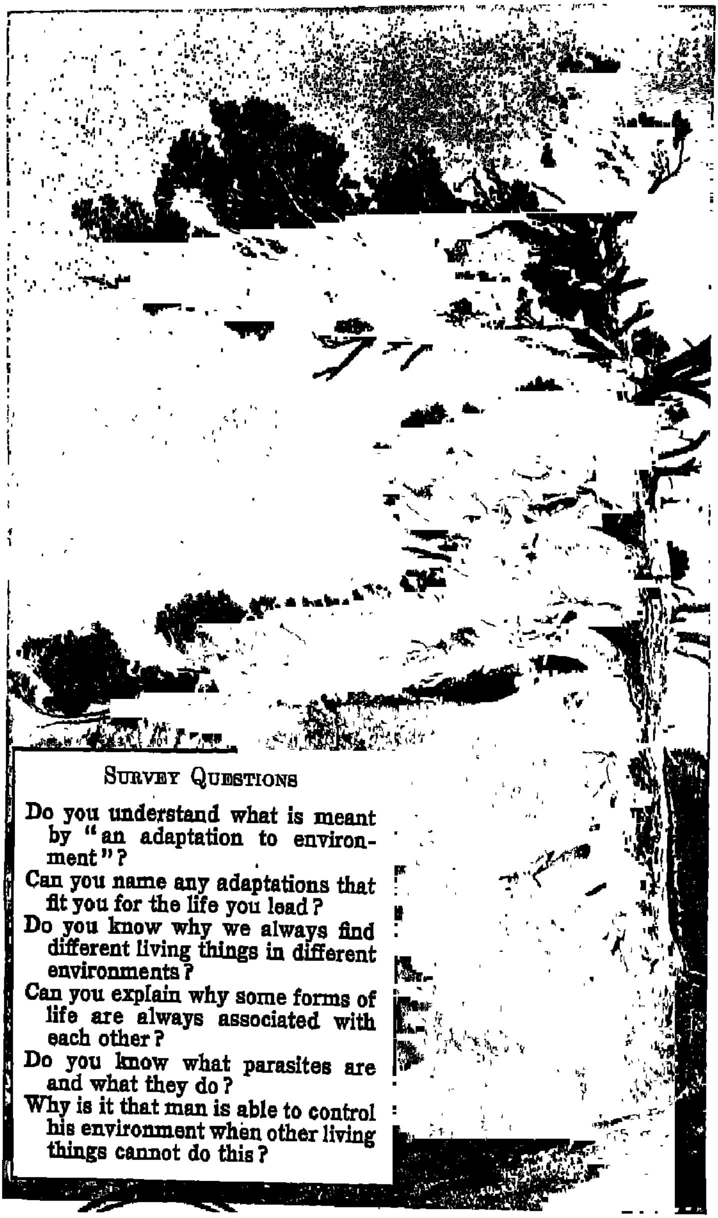


Survey Questions

Do you understand what is meant by "an adaptation to environment"?

Can you name any adaptations that fit you for the life you lead?

Do you know why we always find different living things in different environments?

Can you explain why some forms of life are always associated with each other?

Do you know what parasites are and what they do?

Why is it that man is able to control his environment when other living things cannot do this?

Wright Pierce

UNIT II

ADAPTATIONS AND THEIR VALUE

PREVIEW

Have you ever wondered why it is that we find different kinds of plants and animals in different localities? Life in the ocean is very different from life on land, and living things found in the arctic regions are not at all like those found in the tropics. Of course all animals have the business of breathing, eating, growing, reproducing, and protecting themselves and their young just as much in one locality as in another. But how different a fish is from a bird, or a turtle from a dog. Plants, too, differ greatly in different localities, although they all have the same general problems of life to solve. If you think back to what you already know about adaptations, you will see that the structures which fit an animal to live in the water are greatly different from those which fit it to live on land, and that a desert plant is quite different in structure from one that lives in a pond. Evidently, then, adaptations result in great differences in the lives of plants and animals. To put it in another way, both your pet dog or the choice rose bush your mother has in her garden have adaptations which fit them to live in the environment in which they are placed. But if your dog were an Eskimo dog, he would be very unhappy in warm weather and might die if taken to live in the tropics. The rose bush may be winter killed if we have a hard cold winter. Each and every living thing is fitted for life in its particular environment, and these fitnesses we call adaptations.

Adaptations sort out animals and plants so that they are found in given localities. You might say it is the locality that sorts out the creatures and plants. This in a way is true, but it only sorts out the plants and animals that are fitted or adapted to live in it. You can easily prove this by a visit to a pond which for one reason or another is slowly drying up. As its water surface gets smaller we have an increasing number of new plants and animals which are fitted to live in the damp rich soil of its shores, soil formed largely from the dead bodies of the water plants and water animals that once lived under the surface of the pond. Eventually the pond may dry up and disappear, and an entirely different collection of plants and animals comes to occupy the place where aquatic forms of life once lived. Thus we see a changing life in a changing environment, and we say the environment determines the things that will live there. In this way living things come to be found in communities or associations which are quite different in different localities.

This pond is slowly drying up. Will the same plants and animals live there if the pond disappears?

Have you ever wondered why it is that some people are successful in life while others are dependent and never

earn their own living? We think of the successful ones as having had better opportunities, friends or relatives who gave them a start, or some chance meeting with an influential member of some big corporation. But if we look carefully into conditions, we often find the unsuccessful are handicapped in some way and thus are unable to compete with those better equipped. So it is in the world of living things. In the struggle that goes on, the weaker plants and animals may be crowded out by the stronger. Health and vigor are great assets for success in life. A strong body is very useful if we are to win out in life.

Certain kinds of adaptations have resulted in some plants or animals living at the expense of others. Our pet dog may have fleas. These little pests, while not doing the dog much harm, do live practically at his expense. To be sure they can and do sometimes transfer themselves to us and suck human blood. In the food tube of our pet there are quite likely to be worms which are mess mates, living on the food the animal eats and digests. These worms use some of the dog's food, thus they may do harm since they give nothing to him in exchange. Such organisms are called parasites.

Parasites, both plant and animal, do untold harm. As science has progressed more and more, man has come to realize that much of the damage done to crops and many of the illnesses that he is subject to are caused by parasites. Bacteria, of which we shall learn more later, are among the parasites which do most of the damage, although there are many others, both plant and animal, that cause disease and death. Much of this book is devoted to telling how man has come to resist the attacks of these enemies and will show us how he has become superior to his environment by changing it, thus destroying the harmful parasites by making their environment too unfavorable for them to live in.

Before beginning the detailed study of this unit, take account of your stock of science information about adaptations. You will understand this unit better if you will recall the chief scientific principles you learned as a result of your study of this similar unit last year. You want to build on a sound foundation, and you cannot do this unless you remember the essentials. Some of these are the following:

Science Principles

1. Adaptations are forms or structures which fit animals and plants to live in a given environment.
2. There are adaptive acts as well as adaptive structures.
3. Living things depend upon adaptations.

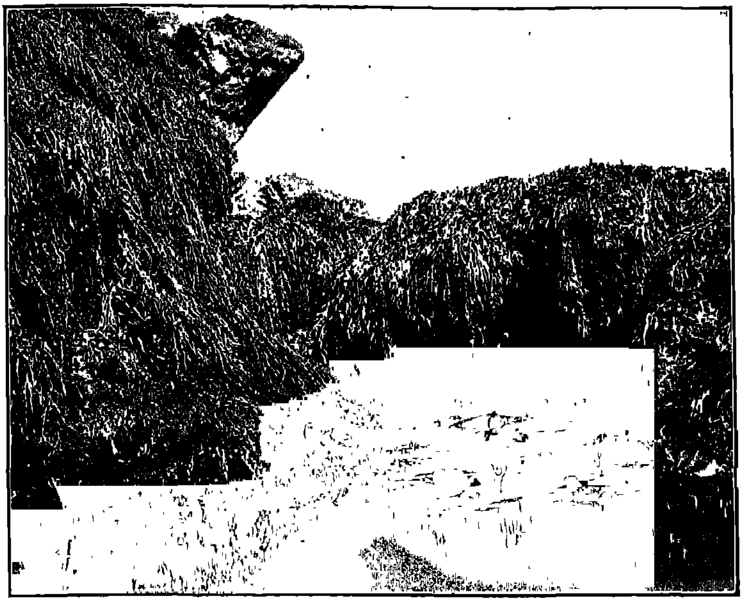
Can you add any to this list?

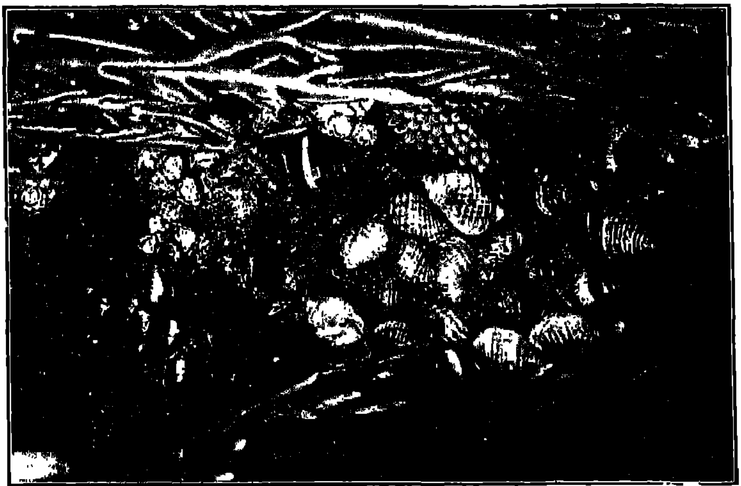
PROBLEM I. WHY DO WE FIND DIFFERENT LIVING THINGS IN DIFFERENT ENVIRONMENTS?

Demonstration 1. To Show Different Adaptations.

Have members of the class bring in pets, and have as much material as is possible exhibited from the school museum to show adaptations. Demonstrate examples of adaptations which fit the animal for food getting, locomotion, protection against enemies, protection of young, and specialized adaptations. Then have members of the class find the same kinds of adaptations in other animals and list these in the workbooks.

There Are Differences in Life on the Seashore and in the Mountains. Any boy or girl who has been to the mountains and the seashore knows that very different plants and animals are found in each locality. The birds which perch in the trees, the animals in the forest, the forest trees, and the ferns and mosses of the mountain side differ greatly from the living plants and animals of the seashore. Here the birds are swimmers or waders instead of perchers, the animals are small and are found in the water along

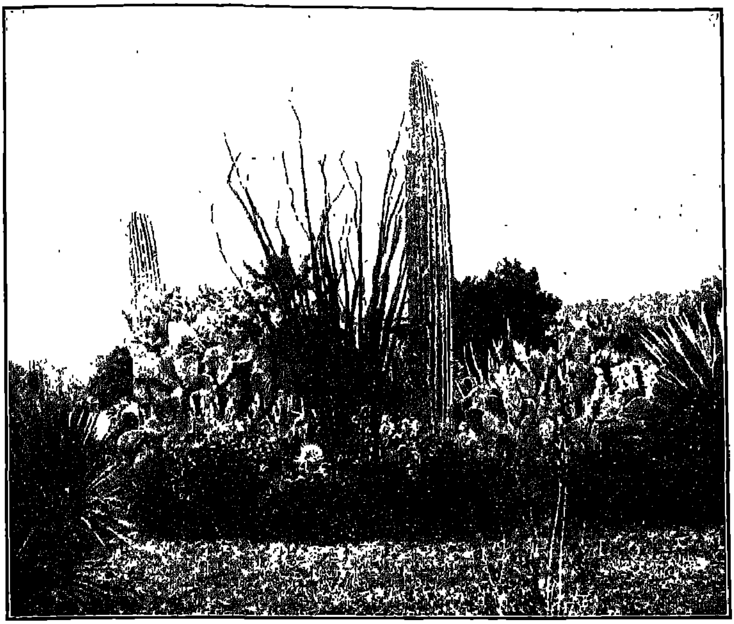




American Museum of Natural History

The upper picture shows a tidal pool. The lower shows a small portion of the same pool. How many forms of life, both plant and animal, can you identify? What other animals would you expect to find in such a pool?

the shore, burrowing in the sand or mud along the shore, or attached to rocks or stones between the low- and high-tide marks. The plants are either seaweeds on the rocks, low creeping plants with thick leaves in the sand, or stunted trees and shrubs close to the coast. Why do we find different living things in different localities? We have already learned that adaptations are structures which fit plants or animals to live under certain conditions. We have also found that living things react or respond to stimuli. That is, they move or respond in some way to forces or things that surround them. Some climbing plants, for example, as soon as they touch an object, will begin to twine themselves around it. An earthworm, as soon as it touches earth with its body, seems to be stimulated to burrow further into the earth, or at least to lie close to it, thus gaining protection. A fish will head up into a current of water, and some insects always fly with a current of air. All of these responses are adaptative because they help the plant or animal to live in its environment. If we try to explain the reasons for the differences between living things found along the shore and those found in the mountains, it is not always easy. We can see that the plants and animals along the seashore have different adaptations from those in the mountains, but why? We have to say, "We do not know" to some of the questions, but experiments have answered some others. We know, for example, that different plants are found in different intensities of sunlight. We call some sun-loving, and others shade-loving plants, and we know that in the deep forest we shall find mosses and ferns that we shall not find in the sun. The salts, found in soils along the shore, are one factor that is responsible for the presence of different plants along the seashore from those of the mountains. Salt-water plants and animals differ from those which use fresh water. As we go up a mountain, the



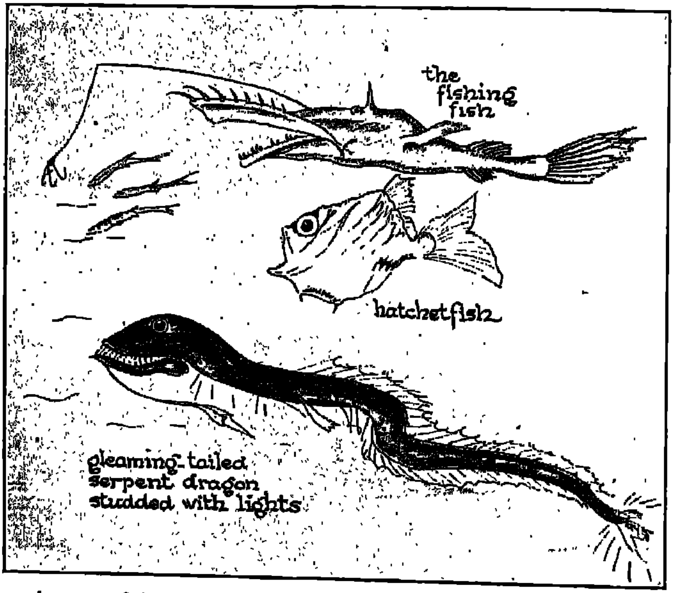
This is a typical desert scene in southern Arizona. Find the home of the elf owl. What other animals might be found living here? How many different plants can you find? What characteristic do they all have in common.

cooler temperature is in a large part responsible for differences in vegetation found in the higher altitudes.

Living Things Are Limited by the Environment. Thus we can easily see that plants and animals in one place are different from those in another place because they are sensitive to the conditions which surround them. Since some are more sensitive to cold or heat or dryness or salts in the soil found in a given locality, they will be found in one place but not in another. The desert quail of California are usually found in the scrub vegetation along river beds, water here seeming to be the limiting factor. Shelter often plays an important part in determining what animals will live in a certain locality. The giant cactus of the western desert often has holes in it which

may serve as homes for a tiny owl, called the *elf owl*. Two species of woodpeckers, a sparrow hawk, a flycatcher, and other birds also make their nests in these holes and are only found in desert regions where this cactus grows.

Adaptations for Life in the Water. Some adaptations for life in different environments are very remarkable; for example, those for a floating life near the surface of the ocean. Living things are found most abundantly in a zone close to the surface, for here food and oxygen are most plentiful. The young of most salt-water animals develop from eggs which are kept near the surface by drops of oil which are lighter than water. When the eggs hatch, the young are often provided with long plumes, spines, or floating hairs. Some animals are bell shaped or umbrella shaped, thus providing resistance against



Three deep-sea fish. What adaptations for life at great depths can you find? Read William Beebe's *Nonesuch, Land of Water*, to find out more interesting things about deep-sea fish.

sinking, and many fish have airbladders or layers of fat which buoy them up. On the other hand, fishes or other animals may live in the deep ocean, far below the area where green plants can survive, for here little light can penetrate. Such fish often carry their own illumination in the form of organs which are phosphorescent. They have large eyes sometimes placed on stalks so as to use what little light there is, for the struggle for food must be very great.

Some Adaptations for Life on Land. Life on land shows more interesting adaptations. We have seen some of the adaptations for plant life on the desert, such as the fleshy stems filled with water, the thick, protective, corky covering, and the substitution of thorns for leaves. Animal life

Galloway *Orient & Occident*

Read your text and then tell where you think each of these photographs was taken. What factor is most responsible for the changes seen in the two pictures?

there is not abundant, being limited to a few centipedes, scorpions, reptiles, birds, and mammals which can survive with little water. Compare this with the life of a tropical forest where rain falls almost daily and where the temperature is always high. Here we have zones of life. Tall trees which rise from 100 to 200 feet into the air, the lower 70 or 80 feet often without a single branch and the upper branches forming such a curtain of foliage that the sun rarely penetrates to the forest floor. In this upper layer of the forest live most of the animals, monkeys, sloths, squirrels, tree raccoons, and myriads of birds. All of these animals show adaptation for life in the tree-tops, as they rarely move out of this upper zone of the forest. An intermediate layer of twisted rope-like lianas

What adaptations can you name in the African elephant? *Galloway*

is then found, which climb upward toward the light, often killing the giant trees on which they climb; while on the forest floor are found shade-loving plants, ferns, mosses, and fungi, with many insects and a few reptiles. These form a third zone of life. On the trunks of trees we find beautiful "air plants" which produce a net-like mass of thick short roots which take water from the moisture-laden air. Everywhere we see adaptations to help the plants and animals survive in a competition that is fierce because of the great number of forms of life crowded into a small ground area.

We might go on and point out adaptations for life in the arctic regions, where a different kind of problem exists for the living things there, or show how changed animals and plants become when they are forced to live in caves away from sunlight, but we will leave that for you to read about in some of the references given at the end of this unit.

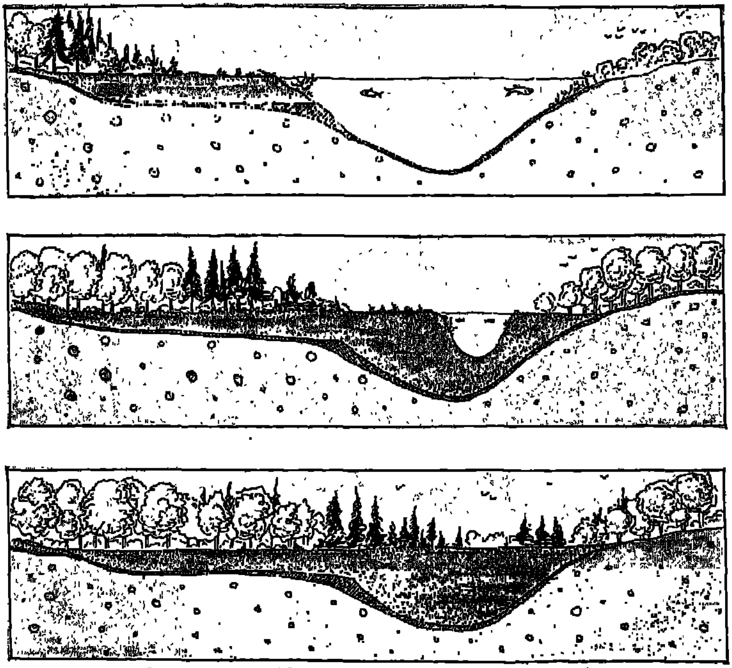
Animals and Plants Form Associations. Plants and animals which live in a given locality seem to have a good deal to do with each other. This is because their adaptations fit them for life under the same conditions. We often find certain insects in the top of an elm tree and other quite different insects living on the trunk, while still other kinds live on the roots. Of course here the factor that determines the presence of the particular insect is the kind of food supplied by the tree. Those at the top of the tree feed on leaves, those under the bark chew the wood, while those which live on the roots suck juices from them. Here the adaptations in the mouth parts of the insect determine where the insect will live. There are over 450 different insects living on the oaks alone, pretty well divided up, some living on the leaves, others in the wood, while others are on the roots. Certain birds are always found in particular localities because the

Find the zones of life represented in this picture. Is the pond getting larger or smaller or is it stationary? Read your text before you answer.

insects or seeds which they eat are present there and nowhere else in that locality. Some soils are better adapted for certain plants and animals as well. We find, for example, that certain plants such as cranberries or huckleberries grow best in soils that are acid, a condition that would result in the death of other plants not fitted to use this part of the soil. Zones of life are found around a pond; in the water, aquatic plants, then a border of low, water-loving grasses and shrubs, and farther back trees which need less moisture. Plants and animals settle down in the place where living conditions are easiest for them, where they can find food, shelter, and conditions of light, temperature, and moisture most favorable to them.

Life Is Continually Changing in a Changing World. Not long ago a group of boys and girls made a survey of the plants and animals living in a small pond in a central western state. They found fish, frogs, many worms, and insect larvae in the water besides myriads of microscopic animals and plants. The pond was located in an old

quarry and was drying up rather rapidly so that two or three years later when another class visited the same area, they found the original inhabitants of the pond had disappeared and that now a new growth of plants and animals had taken the place of those that lived in the water. In other words, a new group of organisms with new adaptations had repopulated this area. The old population had been killed off because they did not have the adaptations necessary to let them live in this changed environment. This story has been repeated many times with many variations. A few years ago our prairies were covered with wild flowers and grasses which today have been almost completely replaced by others brought in



Redrawn from an article by Dachnowski from Bulletin 16, Geological Survey of Ohio

These diagrams show how life is continually changing when some factors of the environment change. What differences can you find?

by man. The prairie hens and quail are both almost extinct and are being replaced by birds which follow man as he cultivates wild land, birds like the English sparrow, starling, or crow. Everywhere we can find life changing if man has come. Ask your grandparents about life in your town when they were children and see what changes have taken place in your locality about which you can tell your class.

SELF-TESTING EXERCISE

Select from the following list the words which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

soil	temperature	adaptations	inhabitants
changes	likenesses	light	changing
new	associations	salts	plow
factors	rain	animals	responsive
conditions	forests	water	plants
differences	dry	static	clouds

There are great (1)____ between the plants and animals found on the seacoast and those of the mountains. These (2)____ seem to be largely caused by the presence of certain (3)____ in one locality but not in the other; while (4)____, (5)____, temperature, and other factors also play a part. Living things are (6)____ to changes in their environment. They are sorted out into different (7)____ which live together because they require certain (8)____ and have (9)____ that meet these conditions. For this reason, life is continually (10)____ on the earth. An area (11)____ because ponds (12)____ up or farmers (13)____ fields or cut down (14)____. Then (15)____ kinds of plants and animals come to take the place of the former (16)____.

ESSAY TEST

Ella Tells about a Tropical Rain Forest

Read carefully and critically. List all the errors and suggest corrections.

I have been reading about life in a tropical forest and have wished that I might visit one sometime. Living animals, especially monkeys, are found everywhere. The trees are short and bushy and

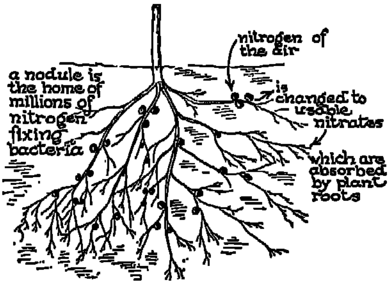
the monkeys climb from one place to another by means of the monkey ladders as some of the twining lianas are called. Most of the birds live near the ground and are very tame. Gorgeous big blue butterflies are numerous as are many other insects. Snakes are sometimes found, big ones, too, and that I would not like.

Since it rains all the time and the sun practically never shines, the forest is dark and damp. Plants grow very rapidly because it is so hot, and form a dense mass of foliage from the top to the bottom of the forest. One has to cut his way through the forest, and that is why explorers know so little about it.

PROBLEM II. WHAT ARE THE RESULTS OF SOME PLANT AND ANIMAL ASSOCIATIONS?

Like Adaptations Cause Associations of Living Things. We have seen that plants and animals come to be associated in the same environment because they both have adaptations that fit them to live under conditions which exist in this environment. Always there is competition in the group, and we find that those which have few adaptations to meet the conditions there may be forced to the wall. Nature has come to their rescue in some cases and we find plants and animals going into partnerships which result in mutual benefit instead of competition.

Life Partnerships. From very early times the Romans knew the value of planting clover or vetch in fields which had lost their fertility so that the following year those same fields would be fertile again. The reason for this was only discovered a few years ago when it was found that certain bacteria lived on little lumps on the roots of clover and other legumes.[1]



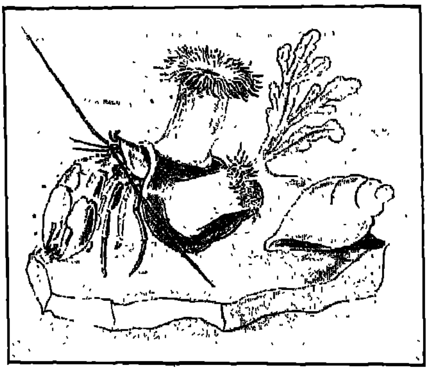
Explain this diagram.

[1] Legumes: A group of plants including peas, beans, clover, and alfalfa.

These bacteria were able to take nitrogen out of the air and fix it so that the clover could use it in making food. So the clover gives the bacteria food and the bacteria give the clover some of the raw food materials and the partnership is complete. Many other such partnerships in which bacteria take part are known. They live in the food tubes of many herbivorous animals and break down the woody walls of plant cells, using them as food and releasing the food inside the cell wall to their partner. We harbor many millions of bacteria, some of which help us in this way.

We have read that green plants make the food of the world. Many animals harbor tiny green plants in their own bodies, giving them protection and some raw materials out of which the plants make food. Some of this manufactured food goes to the animal in which they live. Such are the tiny green hydra which lives in fresh-water pools and some of its salt-water cousins, the reef-building coral polyps.

Symbiosis Means a Joint Life. In our later study of biology we shall hear of many other forms of life which show more or less plainly this "give and take" relationship. Such are the living together of aphids and ants, the aphids being fed and protected by the ants, which use the "honey dew," a sweet secretion given off by the aphids; or the partnership between hermit crabs and sea anemones, illustrated in the



What examples of symbiosis have you found in life in your locality?

Bureau of Entomology & Plant Quarantine, U. S. Dept. of Agric.

Stem rust of wheat has two hosts, the barberry and the wheat plant. The parasite passes a different stage of its life on each plant. How would you go to work to destroy wheat rust?

picture. This partnership for mutual benefit is called *symbiosis*.

Some Partnerships Are One-Sided. Another kind of relationship results out of living together. In such a life one of the associates comes to live at the expense of the other, taking all from it and giving nothing in return. This kind of association is called *parasitism*. The organism which gives the living is called the host; the one which gets it is called the parasite. The world is full of examples of this relationship, most of which result in harm and perhaps an early death to the host. Our pet dog or cat has its fleas and worms. The oak has mistletoe and the rose bush has mildew or blight. The common green frog may harbor millions of bacteria and single-celled animals in his food tube, round worms and fluke worms in his liver, more flukes on his bladder, and scores of other less common parasites in other parts of the body. Man may have

hookworms and other intestinal worms, or he may be afflicted with the parasite that causes malaria or sleeping sickness, or some form of bacterial disease.

Wright Pierce

Mistletoe in a sycamore tree. Have you ever seen mistletoe growing? If so, where?

There Are Several Degrees of Parasitism. In the list of parasites mentioned above, we find several degrees of parasitism. The flea on the cat or dog does not have to stay there in order to live. It can get its living from any number of different animals. The mistletoe usually lives on the oak, but may live on other kinds of trees. It makes its own food in part, taking part of its nourishment from the host tree. It is therefore a partial parasite. But the parasite that causes malaria in man must be placed in the blood of man by a mosquito that carries it or it cannot develop into an adult, and so can never reproduce its kind. All these facts about parasites have been learned after much labor by scientists, so that today man is showing his adaptiveness by using this and similar knowledge to exterminate his parasitic enemies.

SELF-TESTING EXERCISE

Select from the following list the words which best fill the blank spaces in the sentences below and arrange them in numerical order. A word may be used more than once.

drink	partnership	benefit	parasite
symbiosis	supports	mutual	nourishment
host	everything	child	one-sided
shelter	father	needs	mother
food	disease	nothing	partner

Associations of living things sometimes result in a kind of (1)____ in which one (2)____ supplies something the other (3)____ and receives (4)____ or (5)____ in return. This condition is called (6)____ and the organisms live together for mutual (7)____. Another association is (8)____. In this case an animal or plant (9)____ another animal or plant, giving it (10)____ and (11)____ and receiving (12)____ in return. The organism which gives everything is called the (13)____; the one which receives everything, the (14)____. Parasites do much harm in the world by causing (15)____.

ESSAY TEST

Tom Writes about the Life of a Parasite

Read carefully and critically. List all the errors and suggest corrections:

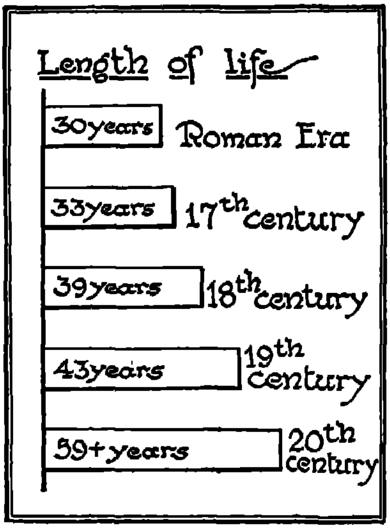
There are very many plants or animals in the world that live together in a very one-sided relationship. One of the two acts as a host of the other, which is content to sponge on its associate for everything, lodging, board, and transportation. They are worse than hitchhikers for they always remain with their host until they kill him. All parasites are larger than their hosts and consequently make short work of them. I think some parasites give their hosts help in making the food they live upon. An example would be the bacteria which live on the roots of the clover plants. Parasites usually find their hosts very early in life and stick to the same host, never changing their position. Consequently they become inactive and die with their host when they kill him.

PROBLEM III. HOW HAS MAN'S ADAPTIVENESS RESULTED IN CONTROL AND IMPROVEMENT OF THE ENVIRONMENT?

Man Can Adapt Himself to New Conditions Better Than Other Animals. You have already heard that man differs from other living things because he can change his environment to suit himself. He does not have to depend

upon the heat of the sun to keep warm. He has harnessed water power and made it produce electricity. He has dug coal and burned it in furnaces to keep warm in winter. He has built homes and put windows in to let light in and keep cold out. He has shown his inventiveness and adaptiveness in hundreds of ways that we shall learn about later. Perhaps best of all man has used the knowledge gained by scientific research to make his life on the earth safer and more healthful.

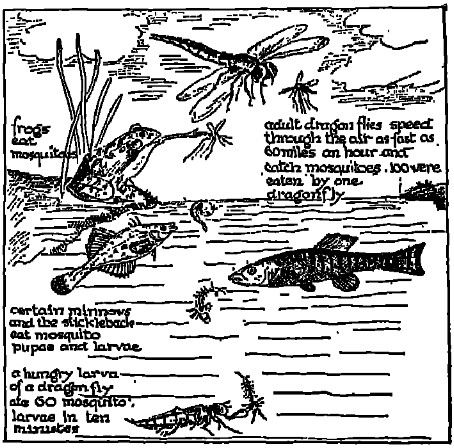
Why We Have Lengthened Our Life Span. We must not think from this statement that science has solved all its problems and cured all our ills. On the other hand, we have scarcely begun to understand some of our problems. But we have made great strides toward longer lives and better health. A glance at the graph below shows how the life span has been lengthened during the past few years. Most of this prolonging of life is due to man's better understanding of the harm done by some of the parasites we have spoken of in the last problem. The lives of hundreds of thousands of babies used to be lost every year by a disease your grandmothers called "summer complaint." Today science has shown that these babies died needlessly, since the disease was caused by bacteria that got into the babies' food. But this is only one factor causing the increase of our life span. Man has found a way to protect himself



How would you account for the lengthening of the life span?

and his family from many other parasitic bacteria which cause disease. He has found that many other parasites besides bacteria do harm and has learned their life habits so that he can destroy them more effectively. He has found that superstition and magic will not ward off or cure disease. In other words, he has come to make use of the work of scientists in making his life on the earth safer. Let us see some ways in which he has done this.

Mosquitoes and Malaria. If you look over some of the salt marsh land along the eastern coast or one of the fresh-water marshes in the South, you will find many small ditches have been dug which quite effectively drain these areas. If you ask someone who lives near this area what it means, he will tell you that this is part of the mosquito-control work in his state. But how does this control mosquitoes and why is it necessary to control them? Although they are pests, should a government go to all the expense of draining area upon area of swamp land? But here is where a knowledge of science and man's adaptiveness come in. Certain kinds of mosquitoes carry the parasite that causes malaria. Scientists have found that mosquitoes lay their eggs in standing water, and that the young are the little wrigglers one often sees in small pools of standing water. If pools of water in the marshes are drained, this will do away with most of the young mosquitoes, and then those that



Explain this diagram. Do you know any other enemies of the mosquito?

Courtesy John L. Wright, Commissioner of Health, New York City

New York City has succeeded in practically exterminating the malarial mosquito by means of oiling its breeding places and draining swamps. Explain why the activities shown in the pictures are undertaken.

hatch can be killed by pouring a film of oil over the pools where they live. Mosquito *larvae*, as the young are called, must come to the surface to breathe, and the oil film gets into their breathing holes and kills them.

An Example of How the Method of Science Was Used in the Discovery of Malaria. The Italians thought, formerly, that malaria was caused by bad air, and hence they called it *mal aria.* In 1880 a French physician named Laveran discovered that malaria was probably caused by a tiny parasite which lived in the blood cells of man. He reasoned that this was so because he found the parasite only in the blood cells of those suffering from malaria. A little later an English army surgeon named Ross, working in India, found, after a long series of experiments, that mosquitoes had something to do with malaria. He knew that they were blood-sucking insects, and that they were always present where malaria was frequent. He reasoned that mosquitoes might carry this germ. He worked a long period of time before he found finally that a certain kind of mosquito, called *Anopheles*, had some unusually tiny bodies attached to the inside of its stomach. These little microscopic bodies were full of black specks. Ross found later that these black specks were only present after a mosquito sucked blood from a person having malaria. By a process of reasoning and experiments, he discovered finally that not only did these mosquitoes carry malaria, but that people could not have malaria unless they were bitten by one of the *Anopheles* mosquitoes, for a malarial parasite has to live a part of its life in the body of the person who has malaria and another part of its life in the body of the mosquito.

Then came the testing of this remarkable theory in Italy. A number of people who worked in a malarial region near the city of Salerno were persuaded to live

in houses which had been carefully screened. It was discovered that the malarial mosquito came out only at night. Practically none of the people who stayed in the

Read your text carefully and then see what liberties the artist has taken with the story told there.

house at night behind their screens got malaria, although almost all of the people in the immediate neighborhood were suffering from the disease.

The final proof came when two English physicians, Dr. Manson and Dr. Warren, allowed themselves to be bitten in England by mosquitoes which had been sent from Italy, but which had been previously fed on the blood of a person having malaria. Neither of these men

had had malaria previously, but eighteen days after they had been bitten, they both came down with the disease. This is an excellent example of how scientific method is applied in the discovery of new facts important to mankind. All we have to do to escape malaria is to be sure that malarial mosquitoes do not bite us. This is only one of hundreds of examples of how the method of the scientist has been applied to control our environment and make for more healthful lives on this earth.

A Study of the Method of Science. If we study this scientific method more fully, we find, first, that the scientist has a reason for trying to solve a problem. He thinks over this problem, and finally gets clear in his mind just what he wants to find out. He has then fixed his *problem*. His next step is to try to find out some *method* or methods of solving it. This he does by thinking over various ways in which he can attack it. He finally fixes on some method which he tries out by means of *experiments* to test whether his theories are correct. He may and often does have to perform hundreds of experiments before he is satisfied that he has a correct solution. This was the case with Dr. Ross as he worked over his problem of how the malarial mosquito played a part in giving the disease to people. At length, after he has satisfied himself that he has the solution to his problem, he must then put it to a practical *test*. This was done, you remember, by the English doctors who allowed themselves to be bitten by the mosquitoes, and thus proved that mosquitoes transmit malaria.

Changes in Man's Thinking Are Taking Place. It is natural that when your father and mother see that you know so much more about the recent applications of science than they do, that they should begin to read and think more about what scientific thinking has done for man. People are beginning to realize that much of

what they read in advertisements and even in the news columns of the daily paper is propaganda and is not based on facts. The scientist wants proof before he believes. He wants to be shown and he wants to weigh evidence before he comes to a decision. Laveran, Ross, and Grassi would never have worked out the life history of the malaria parasite if they had jumped to conclusions. So people today are asking more and more for experimental proof before they accept a conclusion. Unfortunately we still have people who have their pet superstitions. Perhaps you may be one of the number. The fakir and the witch doctor have gone in most civilized communities, but we still have plenty of patent medicines sold without the patient having any scientific advice on the advisability of taking them. And people still drink to excess or smoke more than is good for them. Let us who have had the advantages of training in science do our part by trying to think the way the scientist does and apply his method in our everyday life.

Have you ever seen one of these fakirs? Do not believe all you hear about "cure-alls," especially from the salesman!

SELF-TESTING EXERCISE

Select from the following list the words which best fill the blank spaces in the sentences below and arrange them in numerical order. A word may be used more than once.

forty-three	necessary	believe	lengthened
excited	disbelieve	seventy-four	superstitious
bacterial	shortened	unscientific	suspend
truth	scientific	facts	prevented
trained	scientist	thirty-five	fifty-nine
untrained	experiments	fakirs	unnecessary

The life span in this country has been (1)____ through the applications of science from about (2)____ years in 1870 to about (3)____ years in 1935. Diseases which were once considered (4)____ for children are now (5)____ by application of knowledge learned about (6)____ parasites. But in spite of (7)____ thinking done by (8)____ workers in science, there are still many people who are (9) ____ and who (10)____ everything they read in the papers or hear over the radio. We need more people who are willing to (11)____ judgment until they know the (12)____ on which the conclusion is based, for this is the way the (13)____ has come to know the (14) ____ about the things he (15)____ with.

ESSAY TEST

JACK DESCRIBES THE DISCOVERY OF THE CAUSE OF MALARIA

Read carefully and critically. List all the errors and suggest corrections.

Although malaria is not a very important disease today anywhere in the world, it once was very widespread. Especially in Italy and the southern part of the United States whole regions were considered malarious. The Italians thought the disease was caused by night air and so called it *mal aria*. The first man to find the parasite was Ross, an English army surgeon. He found that the blood of people who had malaria was filled with little black specks. These were the germs that caused the trouble. The disease is caused by a germ which gets into the blood by the bite of a mosquito. Any mosquito will carry this germ, so that is why the marshes are drained and the mosquitoes killed in this way.

THE REVIEW SUMMARY

In preparing a summary of what you have found out in this unit, you will want to place emphasis on the big ideas which have come from the applications of the facts you have learned and the

demonstrations you have seen. Doubtless you have done some additional reading which has helped you put together some of the facts into generalizations or fundamental underlying principles. For this unit these generalizations are:

1. Animals and plants can only live where their adaptations fit them for life.
2. Certain kinds of plants and animals because of their similar adaptations are always found in the same localities.
3. There is usually a struggle for life among plants and animals, and those which are stronger or have the most useful adaptations survive.
4. Some plants and animals have come to live in a state of mutual helpfulness.
5. Some living things have come to live at the expense of others and so often cause disease and death.
6. Man, because of his ability to adapt himself to new conditions, is learning to keep most harmful parasites under control.

Before making your review summary for your workbook, test your knowledge of the facts of the unit by checking over the text so as to be sure you know the facts underlying the science principles or generalizations. Then using this material and everything you have read, seen, or done yourself, make your summary outline. This outline you may use when you make a recitation.

TEST ON FUNDAMENTAL CONCEPTS

In a vertical column under the heading CORRECT *write numbers of all statements you believe to be true. In another column under* INCORRECT *write numbers of the false statements. Your grade = right answers* × $2\frac{1}{2}$.

I. **Adaptations:** (1) are characters which enable organisms to live in a given environment; (2) may be structures or ways of doing something important to the organism; (3) are found in animals but not in plants; (4) are seen in the stripes of a tiger which resemble the shadows made by the tall grass of the jungle in which it lives; (5) are not possible in the desert for nothing can live there.

II. **Plants and animals which live along the seashore are different from those along the shore of a fresh-water lake because:** (6) of the different amounts of sunlight; (7) of the differences in the salts in the water; (8) of the differences in food available; (9) of the sand and rocks along the seashore; (10) of the differences of dirt in the water.

III. **Some adaptations for life in the water are:** (11) scales; (12) gills; (13) legs; (14) fins; (15) nails.

IV. **Zones of life:** (16) are found in a tropical rain forest; (17) are found in a vertical section of the ocean; (18) are found on the surface of the ocean; (19) are seen when we climb a high mountain in the tropics; (20) are caused by adaptations in the inhabitants of these zones.

V. **Associations of animals and plants:** (21) are often found in a given environment; (22) change as the environment changes; (23) are determined by similar adaptations; (24) often depend upon food found in a given environment; (25) might be seen in a school aquarium.

VI. **Symbiosis:** (26) is the name of a certain plant; (27) is never found in the animal kingdom; (28) is a living together in a partnership for mutual advantage; (29) is seen in the case of a bird hatching its eggs; (30) is well illustrated by the association of ants and aphids.

VII. **Parasitism:** (31) is a living together for mutual protection; (32) often results in the death of both parasite and host; (33) occurs when one organism lives at the expense of another; (34) is always complete and never partial; (35) may cause disease.

VIII. **Man's use of the scientific method:** (36) has shown him a way to exterminate many parasites; (37) has given him control over his environment; (38) has lengthened the life span by saving the lives of thousands of babies; (39) has done away with superstition; (40) has resulted in the knowledge of what causes malaria.

PRACTICAL PROBLEMS

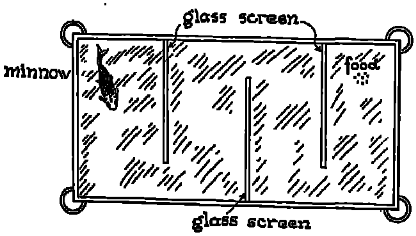
1. How is it that you can swim if you are not adapted to life in the water?
2. Can you give an example of a parasite not mentioned in the text?
3. How does the mistletoe plant get its food from its host?
4. Are there any border cases between symbiosis on the one hand and parasitism on the other? Read Wells, *The Science of Life*, pages 922–936.
5. How can you prove or disprove the statement that horsehairs grow into snakes?
6. Do you use the scientific method in solving your everyday problems? If so, illustrate.
7. Is a cat that catches birds a parasite?
8. Can you show that a well-balanced organism illustrates symbiosis?
9. Are there parasites in human society? Explain your answer.

INTERESTING THINGS TO DO, READ ABOUT, OR SEE

1. Make a chart illustrating the life history of the sheep liver fluke and show how you could eradicate it.
2. Read Paul de Kruif's book, *Microbe Hunters*, and report on some interesting parasite described there.
3. Read the life of some scientist described in the above book and make a report on it to the class.
4. Collect for your workbook all the clippings you can find in the papers which have to do with superstitions.
5. Take one or two of the above superstitions and see if you could disprove them by the use of the scientific method of thinking. (See *My Own Science Problems*, page 7.)

SCIENCE FOR LEISURE TIME

1. Make a trip to the shore and study a tidal pool for examples of symbiosis. Look especially for hermit crabs, sea anemones, small fish, and little crabs.
2. If you live near the mountains, you might make a map showing the zones of life on a mountain side. Get some help from your teacher or from a good biology.
3. Make a trick aquarium with a maze of glass fitted in it like that shown in the diagram. Try to get a minnow, stickleback, or perch to adapt himself to a new situation in his environment by placing the food at the point shown in the diagram. See how many times he tries before he learns to go directly to the food.



4. Teach your pet dog to beg with a lump of sugar balanced on his nose and do not allow him the sugar until you give him the word. Does he finally make an adaptation?

SCIENCE CLUB ACTIVITIES

1. Make a collection of pictures that illustrate symbiosis for the bulletin board.
2. Collect and exhibit the parasites common to your locality.
3. Make a series of photographs showing how mistletoe grows, on its hosts.

4. Take a field trip and bring back as many different examples of symbiosis and parasitism as you can find.

5. Prepare a good specimen of clover or other legume to show the nodules.

6. Make a bulletin-board exhibit showing how people do not use the scientific method in their daily life.

7. Make a collection of the pet superstitions of your class. You can do this by circulating a questionnaire asking your class to be honest and name any they may have.

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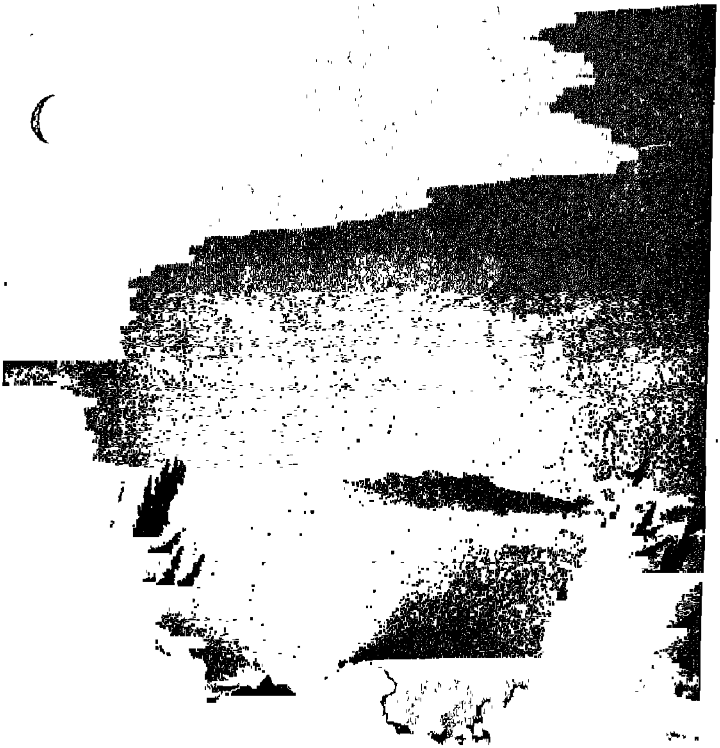


Survey Questions

Why do you need to breathe?

How would you measure your lung capacity?

What makes some air harmful to breathe?

Why are some cleaning methods more desirable than others?

What changes occur in air during respiration?

How can air in our homes be improved?

What is the value of ventilation?

What is meant by "air conditioning"?

R. I. Nesmith

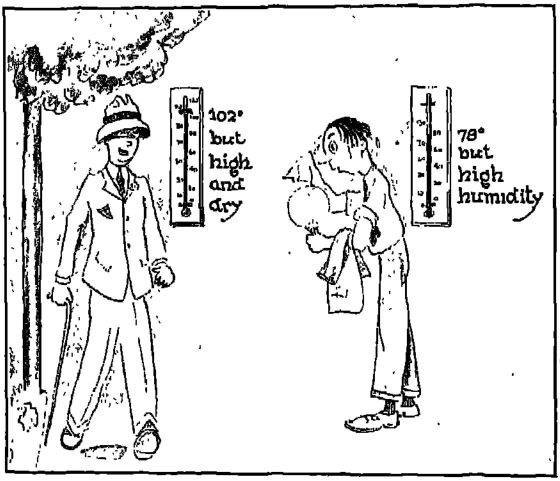
UNIT III

PROPER AIR CONDITIONS BRING COMFORT AND HEALTH

PREVIEW

People talk a good deal about pure air and how important it is. We might ask, What is pure air, anyway? We have seen that air is made up of a mixture of several gases, nitrogen, oxygen, carbon dioxide, water vapor, small amounts of argon, and some other gases. Is this the air that we usually come in contact with? We have to admit that it is not. Dust, smoke, fumes, odors of various sorts, and worst of all, tiny living germs which stick to the dust, are found in most air. A good many years ago the scientist Louis Pasteur proved that germs were found in dusty air. He filled a number of glass flasks with beef broth, a liquid that is easily spoiled by germs. He boiled the liquid and then sealed the flasks while the broth was still hot. Later he opened these flasks at different places, some in a mountain valley in Switzerland, some part way up the mountain on a glacier, and some high up on the summit of the mountain. After opening each flask for a short time, he closed it so as to keep germs from getting inside and brought them all down to his laboratory. Later he found that the broth in some of the flasks had decayed and smelled badly, while in others there was little or no decay. The flasks that were opened on the tops of the mountains remained absolutely as they were, thus showing that the little germs which caused decay were found only in the air that had dust in it.

We used to think that carbon dioxide was very harmful to breathe, but recent experiments show that as long as a good supply of oxygen is present people suffer no discomfort from the carbon dioxide in the air. Another experiment made with people in closed rooms shows that they would be very uncomfortable if they were left for any length of time in a room in which the air was not in motion, but as soon as an electric fan was started, they would be comfortable. Why is this so? Have you ever been in a desert on a hot day? The temperature will be 110° in the shade, if you can find any. Little life will be stirring, birds will be under cover, and there will be a hot breeze blowing. You want water, and you feel hot, but you do not notice that you are sweating very much. You feel the glare of the light and the dryness of the air much more than the



The boy at the left lives at an altitude of 5000 feet above sea level where the climate is hot and dry; the boy at the right lives near the coast where it is not so hot but where there is much moisture in the atmosphere. Why is he so uncomfortable?

heat. Contrast this experience with that of a hot, muggy day on the New England coast. Here if we could compare

the temperature with that of the western desert, we would find it at least 20° cooler. But we feel hotter and suffer more from the heat. There is a little breeze, but your skin will be covered with beads of perspiration. How do you account for this difference in your feelings? In one case the temperature is actually much hotter, and yet you do not feel so uncomfortable. You say it is due to the humidity.

The question then comes, What is humidity and how does it affect us? When particles of water vapor are in the air, they are said to make the air more moist or humid. If there was no water vapor at all, we would have zero humidity, and under some conditions we get a humidity of 90 or even 100 per cent. When this water vapor becomes high, it surrounds the body with a blanket of warm saturated air. If you put a blanket around your body on a hot day, you would be uncomfortable. In the same way this blanket of nearly saturated air prevents the heat from getting out of the body. Just how this is done and just why we are more comfortable on dry than on humid days are questions which will be answered later in this unit.

Before you begin your study of the pages which follow, you will want to recall the most important scientific principles you learned last year in your study of a similar unit on air. You cannot expect to build without a sound foundation, and in order to have that, you must remember the essential facts you learned about the air. They are the following:

Science Principles

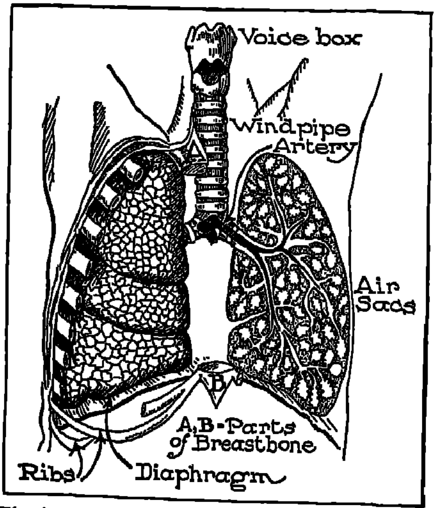
1. The atmosphere is all the air that surrounds the earth.
2. The atmosphere because of its weight exerts pressure upon everything with which it comes in contact.

3. The air contains elements essential to the lives of plants and animals.

4. Many changes that take place in nature are due to the presence of the air.

PROBLEM I. WHY WE BREATHE

We learned in our science of last year how the lungs take in air. But we did not ask why this process is so necessary. We saw that the lungs were in reality two bags connected by a tube with the outside of the body. We found these bags were placed in an air-tight cavity and that air was taken in or expelled from them by the action of the ribs and muscular diaphragm which formed the lower wall of the chest cavity.



The human breathing organs. Notice one lung is cut open to show the air sacs.

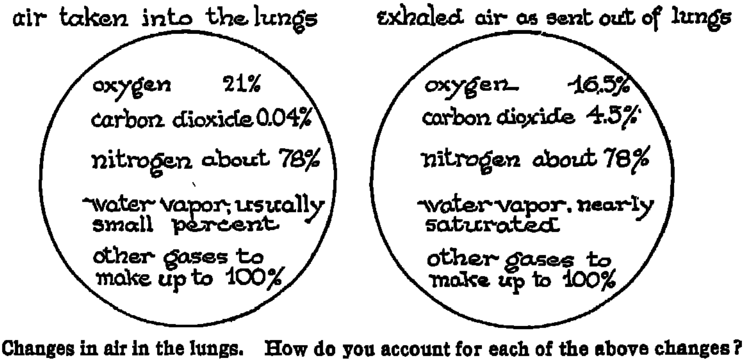
Let us now go into a little more detail on the structure of the lungs and see why breathing is necessary for the running of the body machine. If we were to examine a lung that was cut open, we would find it made up of little air sacs such as are shown in the diagram. If one of these air sacs were examined under the microscope, its wall would be found to be a mass of tiny blood vessels, which were so placed that they lay close to the cavity of the air sac. There must be a reason for this. What is it?

Demonstration 1. To Determine Some Products of Respiration.

Method and Observations: Blow the breath through a large dry glass tube until there is evidence of something deposited on the inside of the glass. From its appearance what do you judge this to be? Blow the breath through limewater in a test tube for a short time. What change occurs? Recall the meaning of this test, which was shown in Unit III of *My Own Science Problems.*

Conclusion: What are two substances produced in our bodies which escape in our breath?

How the Air Is Changed in Our Lungs. When we test the air coming out from the lungs, we find it different from the air that went in. In the first place, it is much more moist. Tested with limewater, we find more carbon dioxide in it. If a careful analysis were made, it would be found to have the same amount of nitrogen but about 4 per cent less oxygen. Evidently, then, this oxygen has stayed in the body while carbon dioxide and water have passed off in the breath.



Changes in air in the lungs. How do you account for each of the above changes?

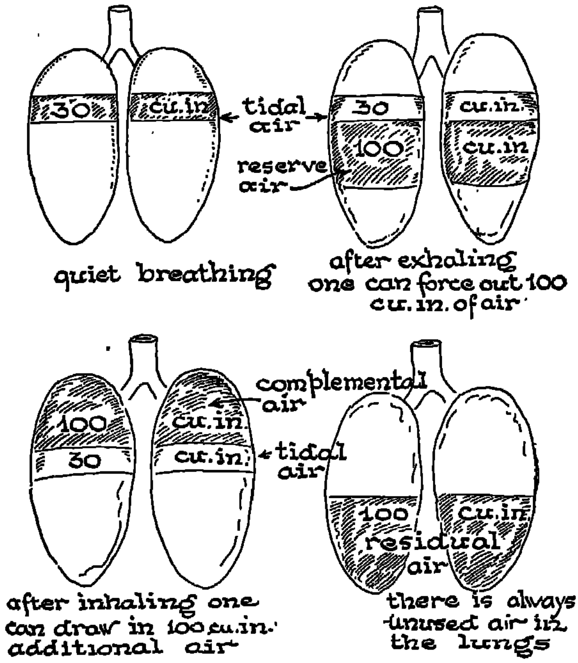
What do these changes mean? From what we have just read it is evident that when air goes into the lung sacs it has relatively more oxygen and relatively less carbon dioxide and water vapor than when it is expelled from the lungs. This seems good evidence that the human body is like an engine, for these products found in the air which

passes off from the lungs are found in air passed off when we burn anything. Think back to your demonstration of last year when fuels were burned.

The Necessity for Deep Breathing. The blood carries back to the lungs the carbon dioxide which has been formed in the cells as a result of the work done there, and this carbon dioxide, as we have seen by our experiment, is given off from the lungs when we exhale. The lungs during ordinary breathing do not expel more than one eleventh of their total capacity. More of the air in the lungs can be expelled when we take a deep breath, but there is always some air left in the lungs. This air must be very impure, as it lacks oxygen and has much carbon dioxide and other waste products as well. It is therefore highly important that we force out as much of this air as possible rather frequently, and we can do this only by deep breathing. We must have as much fresh air as possible, our rooms must be well ventilated, porous clothing should be worn so that the body can have a constant air bath, for the skin under the clothes needs air as well as the parts exposed. We have come to depend upon outdoor play and outdoor sleeping as means of good health. We should always practice good posture and acquire good breathing habits. An excellent habit is that of morning exercise with the windows thrown open. Remember that the lungs need exercise and air, and that only by deep breathing which expels much of the stagnant air which accumulates in the lungs can we make them resistant against disease germs.

Lung Capacity. From figures obtained in a large number of measurements, not only the average capacity of the lungs but the volume of air changed under various conditions of breathing have been determined. In ordinary quiet breathing about 30 cubic inches of air pass in and out of the lungs. This is called *tidal air*. After exhaling

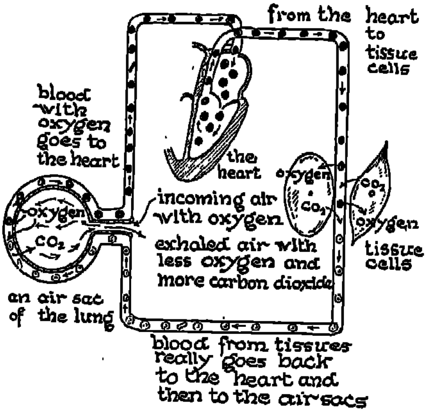
an ordinary breath, one can force out about 100 cubic inches of air in addition to the tidal air. This is called *reserve air*. After inhaling an ordinary breath one can, by taking as deep a breath as possible, take in about 100 cubic inches of air more. This, scientists call *complemental air*. There is always about 100 cubic inches of air left in the lungs even after forcing out all that one possibly can. This is the *residual air*. You can see from



What is the advantage of deep breathing? Figure out the amount of air you would use in 5 minutes when you are asleep if you take 12 breaths a minute. How much would you use in the same period of time when you are exercising hard, supposing your rate of breathing increases to 20 a minute?

the diagram why deep breathing becomes necessary when we exercise vigorously and why it is a good thing for us to do this frequently.

The Real Reason for Breathing. Most boys and girls think that breathing takes place in the lungs. This is true, but we would soon die if the oxygen stopped there. As a matter of fact, the lungs are simply organs which serve to turn oxygen over to and take carbon dioxide and waste matter from the blood. The real respiration takes place in the cells of the body which do work for us. If we work a muscle of the arm, then that muscle in order to do its work must oxidize some fuel or food material which has been carried to it by the blood. If we work with the brain, then food must be oxidized in the brain cells in order that energy may be released there. The blood, like a railroad train, carries the oxygen from the lungs to all places in the body. In the blood are little cells known as red corpuscles having the ability to carry oxygen. They are also able to give up oxygen where it is needed in the body. Thus the blood becomes a medium of exchange between the cells and the air which is taken into the lungs. The products formed when oxygen is used in the body are exhaled in the breath and may be detected by simple tests.



What does this diagram represent? Explain.

SELF-TESTING EXERCISE

Select from the following list the words which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

air	food	thin	gain	30
gases	sacs	130	produce	lose
230	less	oxidize	more	water
cells	lungs	60	100	waste
330	blood	breath	use	carbon dioxide

Air expelled from the lungs has (1)____ carbon dioxide and water vapor and (2)____ oxygen than air which is taken into the lungs. This is because the (3)____ of the body (4)____ food when work is done and thus (5)____ oxygen and (6)____ carbon dioxide and water as (7)____ products. The (8)____ carries the oxygen to the (9)____ and returns the carbon dioxide and water to the (10)____. The exchange of (11)____ and (12)____ takes place in the air (13)____ which have very (14)____ walls. The lungs have a capacity of about (15)____ cubic inches of air, of which (16)____ cubic inches always remain. A very deep breath will take out about (17)____ cubic inches although in quiet breathing we rarely change more than (18)____ cubic inches of (19)____ in a single (20)____.

ESSAY TEST

HARRY TELLS WHY WE BREATHE

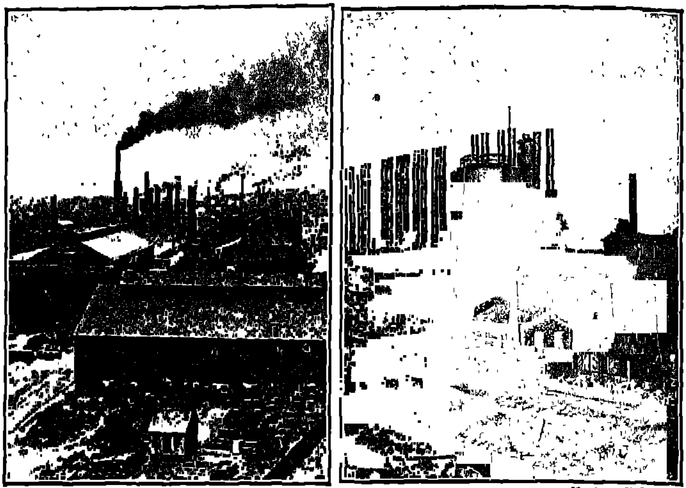
Read carefully and critically. List errors and suggest corrections.

All living things that do work have to breathe. This is because they are like engines which cannot burn coal or oil in the fire box unless it is mixed with oxygen. It is really the oxygen and nitrogen of the air that are used in the lungs where food is oxidized. We carry food to the lungs in the blood and when we breathe, the oxygen of the air unites there with the food, releasing energy to do work. That is the reason why heat, carbon dioxide, and water vapor are passed out in our breath.

PROBLEM II. WHAT CONDITIONS OF AIR ARE MOST FAVORABLE TO MAN?

Demonstration 2. To Prove that Germs Are Associated with Dust in the Air.

Take three sterile Petri dishes containing culture media. Label them 1, 2, and 3. Expose #1 by taking off the cover for three minutes in a schoolroom where dusting is being done with a dry cloth or duster. Expose #2 in the same room for three minutes when no movement of air is taking place. Keep #3 closed for a control. Place all three in a warm place for three days. What results do you find?

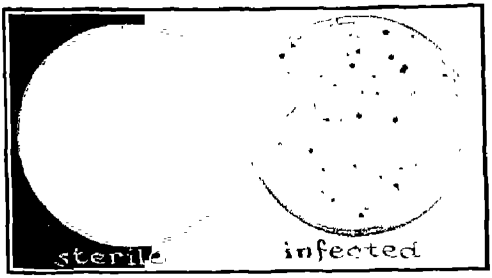


Ewing Galloway

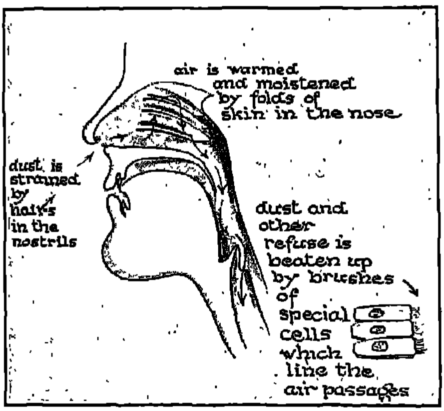
Views of two plants: one wasting much fuel in smoke, the other saving fuel by use of smoke consumers.

Dust and Its Dangers. Pure air is a mixture of several gases and water vapor. But you know that most air contains some impurities. In cities where soft coal is burned, over 60 per cent of the dust is made up of unburned particles of coal. In such cities as Chicago, St. Louis, or Pittsburgh before smoke consumers were placed in chimneys, as much as 1000 tons of solid material, mostly soot, were placed in the air every year. This soot is deposited on our clothing and furniture and is very irritating to the nose and throat. Worse than this, smoke and dust screen out the health-giving ultra-violet rays of light from the sun. But dust comes from other sources. Rocks, ground up by the force of water, wind, and frost, become powder and get into the air as dust when the wind blows. Sometimes volcanic eruptions which blow off the tops of mountains throw thousands of tons of dust into the upper atmosphere. After an explosion of the volcano Krakatoa in the East Indies in 1883, four cubic miles of

mountain was blown into dust. This dust remained in the atmosphere for several years and passed completely around the world. We had a similar experience in 1934 when the wind carried dust from the drought-stricken states west of the Mississippi River as far east as New York. Then we have evidence of millions of little organisms in the air. If you take two sterile Petri dishes filled with absolutely sterile culture media, a substance made of beef broth and gelatin, and expose one to the air in a schoolroom while dust is being stirred up by the movement of people, and the second in the same room when the air is quiet, then put them away in a warm place for two or three days, little growths will appear on the surface of the culture media, but most of the growths will be found in the dish exposed to the dusty conditions. If these growths are examined under a compound microscope, they will be found to be small colonies of tiny organisms called bacteria. Most of



Two Petri dishes with sterilized culture media. The one at the right was exposed to the air, the one at the left is a control. How do you account for the spots in the one dish?



Follow a dust particle into the nose and show what happens to it there.

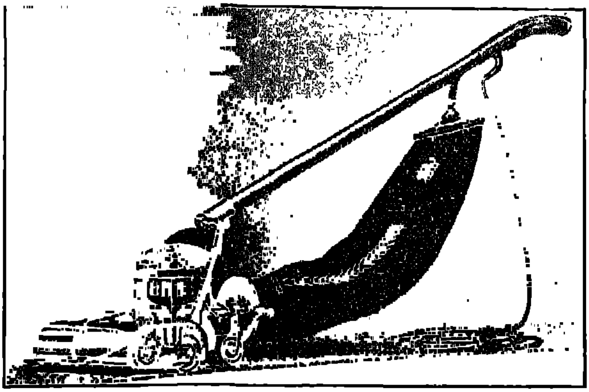
them are harmless but some may be very dangerous and cause disease. These bacteria are little plants, and there are other tiny plants also found in the dust, called *yeasts* and *molds*.

How the Organs of Respiration Are Protected from Dust. The nose, the organ of smell, performs several other very important offices. Just near its entrance are many hairs which the air must pass. Down below, in the throat itself, is a soft lining of cells which are provided with tiny whip-like structures made of living matter. These structures, called *cilia*, are constantly in motion, and always whip upwards so as to expel all foreign material from the lungs. The ciliated cells, together with the hair in the nose, prevent most foreign matter, such as dust and dirt with their load of germs, from going down into the lungs. The lining of the nose also moistens and warms the air before it passes to the lungs.

Hay Fever. The disease known as hay fever seems to be caused by dust made up of pollen from different kinds of flowers. This pollen is a violent poison to some people, and causes sneezing, itching eyes and nose, and a feeling of discomfort. No real cure has been found except innoculation with various vaccines made from the agents which cause the trouble. A similar disease called asthma is often caused by food poisoning. The cause of the trouble can often be discovered by means of a skin test in which a tiny portion of the suspected food is placed in a small scratch on the arm. A similar scratch is made without the food substance as a control. If a redness and swelling occurs in the scratch containing the food substance, then we may know that the person is sensitive to this food and should not eat it.

Proper Methods of Sweeping and Dusting. It is important not to stir up any more dust into the air than is necessary when we sweep or dust. For those who

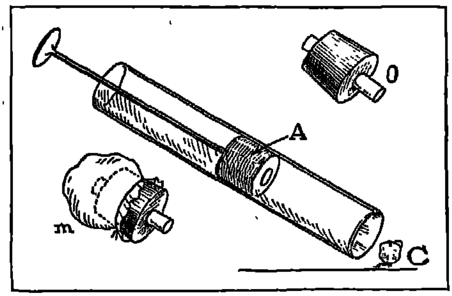
have electricity in their homes, the vacuum cleaner is the safest and best method of cleaning. A damp or oily



Can you explain the principle used in this sweeper?

cloth should be used on polished surfaces such as floors and furniture. Rugs are much better than carpets because they can be taken out of doors and swept instead of stirring up the dust inside the room.

The Vacuum Cleaner and Sweeper. The electric vacuum cleaners are of two types. One produces a vacuum by means of an air pump of the piston type, the other by means of a fan. A higher vacuum can be produced with a pump but it is hard on the rugs and carpets. The principle of vacuum cleaning is easily demonstrated



A vacuum cleaner that you can make. Read your text to see how it works.

by holding the end of a glass tube near a loose ball of paper (*C*) and drawing up the piston (*A*). A vacuum is produced in the tube, and air rushing into the tube

pushes the paper along with it. By making the opening (O) smaller by using a stopper with a small tube, sand may be forced into the tube, and if a piece of muslin cloth (m) is fastened over the inside of the stopper near the end of the larger tube, this will hold the sand and dirt which enters, but will allow the air to pass on. This illustrates the use of the bag for holding the dirt in the pump cleaners. In the fan cleaners, however, the dirt and air are blown into the bag. The dirt is held here by the tight, close mesh of the cloth, but the air passes out into the room again after being filtered through the cloth.

Why Is Oxygen Important? In the last problem we saw that the air is a mixture of gases and that nitrogen forms by far its greatest bulk. We have already seen that oxygen makes a fire burn, and that it sustains life because it allows us to oxidize food substances in the body, thus releasing energy. Fortunately for us it is diluted in the air, for otherwise fires would be much more dangerous. You may have seen an oxyacetylene torch which is used for welding metals. In an atmosphere of pure oxygen, metals would burn and fire would be uncontrolled. We know that workers in compressed air under water are "pepped up" by the extra oxygen that is given them when the air is put under pressure. We know that oxygen is

Galloway

Using an oxyacetylene torch. Why are the eyes of the worker protected?

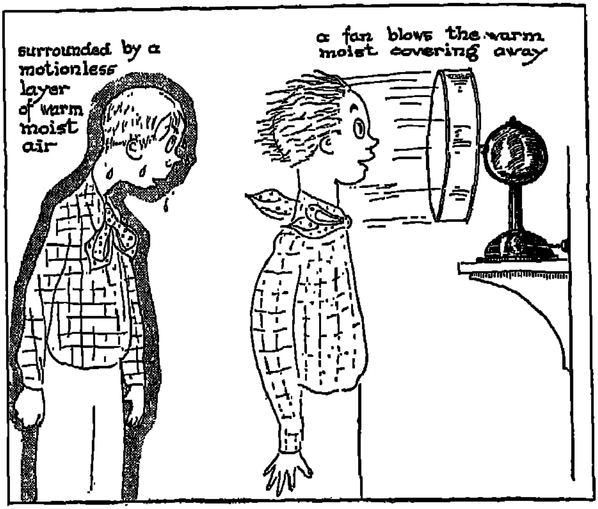
sometimes given to sick people in order to keep them alive, and in many other ways it is a servant of man.

Is Carbon Dioxide Harmful? We have seen that carbon dioxide is a gas that is formed when substances burn. In an experiment in which a candle was burned in a closed jar, we found the candle went out, leaving a colorless and odorless gas, heavier than air, which turned limewater milky. Carbon dioxide is not as poisonous as was once believed. Experiments made under school conditions show that students can work in an atmosphere containing at least ten times as much carbon dioxide as in ordinary air without any apparent ill effects, and in an experiment performed in England a few years ago, not only was the carbon dioxide increased to 4 per cent, but the oxygen of the air was cut down from 20 per cent to 17 per cent and yet the students suffered no discomforts.

Dangers from Carbon Monoxide. We should not confuse the poisonous gas, carbon monoxide, with carbon dioxide, which is harmless to health. Carbon monoxide forms as a result of incomplete combustion and is found in gases given off from the automobile when you cut off the air by using the choke. It is also made in abundance when coal is put on a fire and the draft is closed. If the damper on the stove pipe of a coal range is closed too soon after putting on coal, smoke highly charged with carbon monoxide escapes into the room. This produces a serious danger because less than 1 per cent of carbon monoxide in air will cause death.

Other Sources of Impure Air. Sometimes open drains, vents from cesspools, and improperly installed drainage pipes allow sewer gas to enter the house. A leak in the gas pipe adds carbon monoxide to the air. Gas discharged by chemical plants, by various trades and industries, is often carried considerable distances by the winds to residential districts, where it pollutes the air.

Effect of Humidity. Have you ever sat in a school assembly on a hot day and felt the room seemingly get hotter and hotter until by the end of the period it seemed



Explain why you are so uncomfortable in a closed room without any air moving.

almost too hot to bear? Yet if you could have watched the thermometer in the room, you would have been surprised to find that it was little if any higher than at the beginning of the period. How can we explain this sense of discomfort? We have learned that there is always some water vapor in the air and that this varies greatly depending on where we are. Some areas, like the desert, have very low humidity, while others, especially cities located along our eastern seaboard, have relatively high humidity. To come back to the assembly period. As the young people sat in the room, water vapor was passed off in the breath, thus raising the humidity. At the same time moisture was passing off from their bodies in perspiration so that after a short time each one became surrounded with a layer of moist, warm air. This layer prevented further

evaporation of perspiration, and so they became more and more uncomfortable.

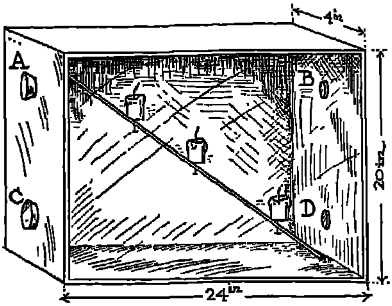
Air Conditions Favorable for Health. You have also experienced the relief that came when the electric fan was turned on in a hot room. Why is this? Simply that when the air is set in motion by the fan, it carries off heat from our bodies by promoting evaporation. A few years ago a commission to study the problem of proper ventilation was appointed by the Governor of the State of New York. This commission was at work from 1912 to 1929 and found out a number of important scientific facts which can be applied to the ventilation of buildings. Among these are that body odors and unpleasant odors, though not dangerous to health, do keep people from being comfortable in a room, that too little humidity is dangerous for health just as too much humidity makes one uncomfortable, that temperatures over 68° with little humidity and little movement of air are bad for health, and that the best conditions for active work are a temperature of about 66° with a relative humidity of 50 per cent and some movement of air. In the home, especially if we are sitting reading or studying, a temperature of 68° with a humidity of 50 will be more comfortable. Older people, or those who are not strong, may need a slightly higher temperature.

Demonstration 3. What Are the Principles Involved in Ventilation?

Materials. A ventilation box. This is to be about 20 inches tall, 2 feet long, and 4 inches thick, having one of its large surfaces of glass. Either the front or back should be grooved to facilitate opening. A slanting shelf one inch wide runs from one lower corner nearly to the opposite upper corner. One-inch holes are bored in the sides as suggested by the letters *A* to *D* in the diagram. Corks are used to close these holes. Three small candles are placed on the diagonal shelf equally spaced so that they are at different levels.

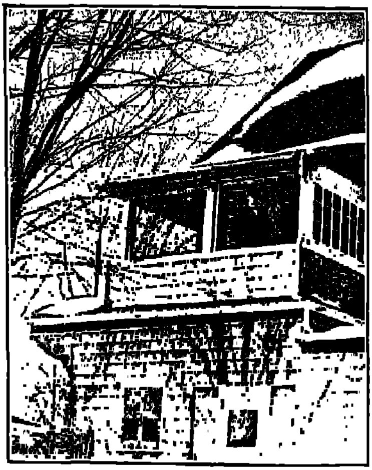
Method and Results. (1) Light the three candles. Close all the openings. Which candle goes out first? Explain why. (2) Light the candles. Open holes *B* and *C*. Test currents of air by hold-

ing a smoking joss stick or rolled paper at the openings. Result? (3) Repeat, using holes *A* and *D* open. (4) Repeat, using *D* and *C* open. (5) Repeat, using *A* and *B* open.



Conclusions. What facts about circulation of air are shown by the demonstration? What facts about changes in air are due to burning substances? What facts are indicated which will be helpful in planning circulation of air in our homes? What conditions found in the experiment are not duplicated in a room where we wish to apply the principles of ventilation? In what particulars can we apply the results found here to ventilation of rooms where people are congregated?

Reason for Ventilation. The best reason for ventilation, therefore, is that the movement of air removes the excess heat from our bodies. It is a good thing to get the body used to moving air provided that air is not cold enough to chill. We also want to get rid of "crowd" odors and sometimes the excess moisture that passes off from their bodies. On the other hand, in bedrooms at home ventilation is used for another purpose. Here we wish to sleep under air conditions as nearly like outdoors as possible. So we open our windows, top and bottom, at night, taking care not to have a direct draft on the



Anyone living in a house can have a sleeping porch. Where was this one placed? What value has a sleeping porch?

bed. For those who can manage it, a sleeping porch is the ideal condition because one can undress and dress in a warm room and sleep in a cold, airy one.

SELF-TESTING EXERCISE

Select from the following list the words which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

sunlight	two	dangerous	monoxide
vacuum	dust	humid	evaporation
17	dustless	dry	stagnant
humidity	30	heat	organisms
top	4	cold	health
one	bottom	unpleasant	cleaning

Air is seldom free from (1)____ and harmful (2)____. Dustless (3)____ is important for our (4)____. For this reason the (5)____ cleaner is desirable. An increase of carbon dioxide up to (6)____ per cent and a decrease in oxygen down to about (7)____ per cent do not bring discomfort, but excessive (8)____ and (9)____ are very oppressive. On the other hand, (10)____ per cent of carbon (11)____ may cause death. Movement of the air helps to remove (12)____ and (13)____ air and promotes (14)____ of perspiration. Natural ventilation is best secured in a bedroom by opening windows (15)____ and (16)____. Body odors may be (17)____ but they are not (18)____ to health.

ESSAY TEST

Edith Discusses Favorable Air Conditions

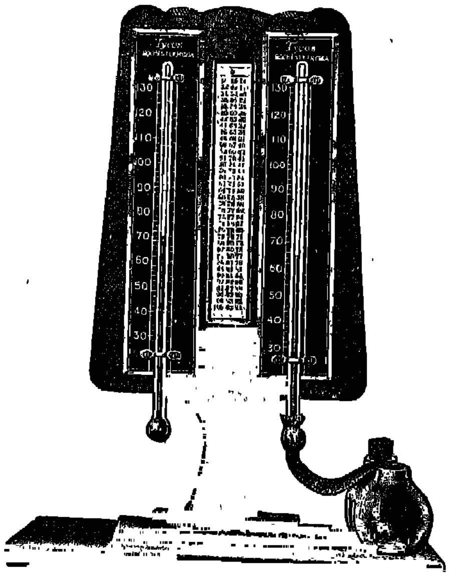
Read carefully and critically. List all the errors and suggest corrections.

There are very delicate tissues in our lungs, which are adapted only for exchange of gases. When solids, as sand particles, soot, plant pollens, and other forms of dust, enter the lungs, they generally produce irritation. There may be bacteria upon the dust particles but since they are only soft plant structures, they are never harmful. The best way to clean in the house is to remove the dust from tables and furniture with a feather duster and a little later, when the dust has settled on the floor, to remove it with a vacuum cleaner. Since carbon dioxide is not a poison, there is no need of ventilation in the daytime. At night it is well to have

circulation of air in the room from a window opened at top and bottom. In winter it is usually desirable to dry the outdoor air before sending it into the rooms because damp air feels chilly.

PROBLEM III. WHAT IS MEANT BY "AIR CONDITIONING"?

We know that ideal conditions of air can be had, but they do not always exist. We may, for example, have a hot humid day in summer so that the indoor temperature rises many degrees above the "best" temperature of 68°. We also know that the humidity of the air may differ greatly. In winter in an overheated room there may be as little water vapor as in the air on the Mojave desert, or the early morning temperature of the house may be down far too low for comfort and health. At times the air of the room may have much dust, containing many bacteria. All of these things are likely to happen and sometimes several of them happen at once.

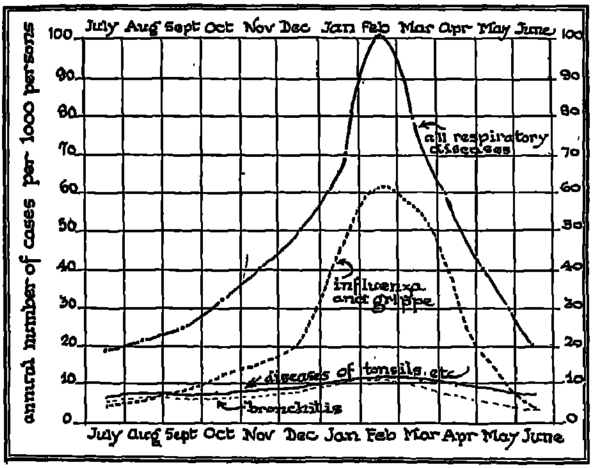


Wet and dry bulb hygrometer. What purpose does this instrument serve?

What Is Meant by Relative Humidity? Girls know that clothes on the line dry quickly on some days and slowly on others, depending not so much on the temperature as on the moisture content of the air. At a given temperature there is a limit to

the amount of moisture the air can hold. When it holds all it can, it is said to be *saturated.* Saturated air is 100 per cent humid. If the air holds half enough water vapor to saturate it, it has a relative humidity of 50 per cent, usually expressed by just the number 50. It is thus seen that *relative humidity* is the per cent of saturation of the air. Clothes will not dry at all in air with a relative humidity of 100, but will dry at any lower humidity. This principle of evaporation of water into unsaturated air is made use of in measuring the relative humidity of the air.

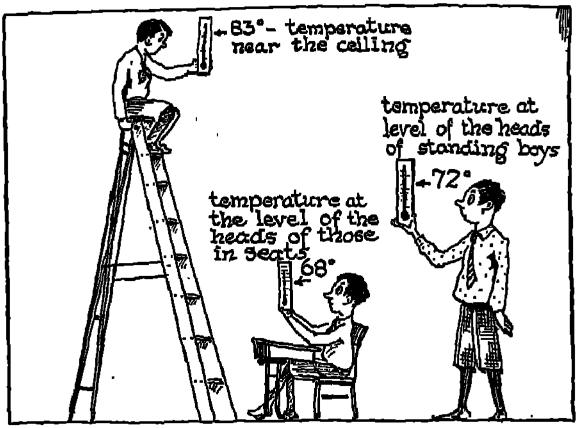
Humidity and Health. Cold winter air that comes into the house holds far less moisture than the warm summer air. Heating the cold air increases its capacity to hold moisture, but does not add moisture. Consequently, heating reduces the relative humidity. When the relative humidity is low, say below 40, evaporation



Why are respiratory diseases so much more prevalent in February than in July?

from the skin is very rapid and takes so much heat from the body that one feels chilly. If the temperature is raised until one feels comfortably warm, the capacity of

the air to hold moisture is raised again and makes the relative humidity still lower, thus increasing evaporation from the skin and air passages. In the winter, with



Can you give a scientific reason why the air at the top of the room is so much hotter than air near the surface of the floor?

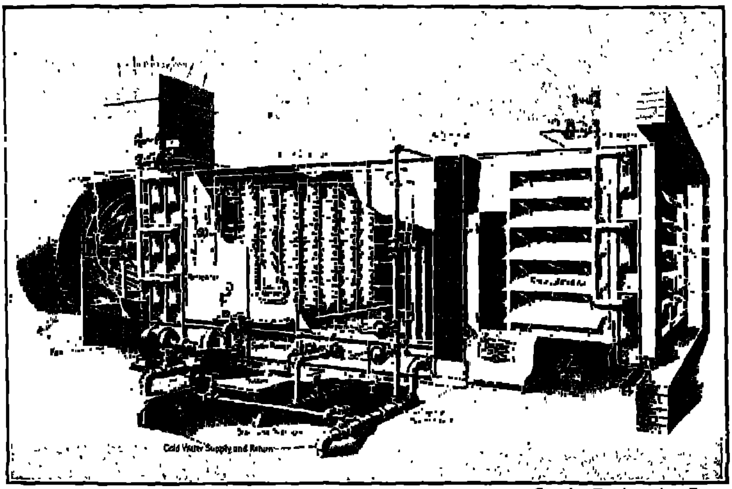
doors and windows shut and the air fairly dry to begin with, furnace heat soon greatly reduces the humidity of the air. As the humidity gets less, we notice the cold more because water evaporates from our skin more rapidly in dry air. Consequently we raise the temperature far too high, and when we leave the room, we get chilled from a draft and take cold. Very hot dry air causes the mucous membranes of the nose and throat to become irritated. This irritation causes roughness and swelling in the tissues, thus giving "cold" germs an opportunity to multiply there. The graph on page 79 shows how close the relation is between respiratory diseases and the use of our artificially heated houses. Much of this sickness could be avoided by properly humidifying the air.

Air Conditioning in the House. Two serious faults with many of our heating plants are that they fail to give even distribution of heat and proper humidity. In many

homes air in a room may differ as much as 15° in temperature between the floor and ceiling. An attempt is sometimes made to moisten the air by using pans of water on the registers or radiators, but without much success.

At the White House Conference on home building and ownership held in 1932, much interest was shown in discussions relating to making the air conditions in the home more suitable for health and comfort. For many years, some movie houses, churches, and auditoriums have had machinery installed which not only controls humidity, but also washes the impurities from the air and keeps it at an ideal temperature.

Apparatus is now on the market which not only automatically cleans the air of dust and soot when it begins to circulate, but also warms it and adds enough water to keep it at a relative humidity of about 50, which seems best for winter. In summer an apparatus may be used to clean, cool, and de-humidify the air.



Carrier Engineering Corp.

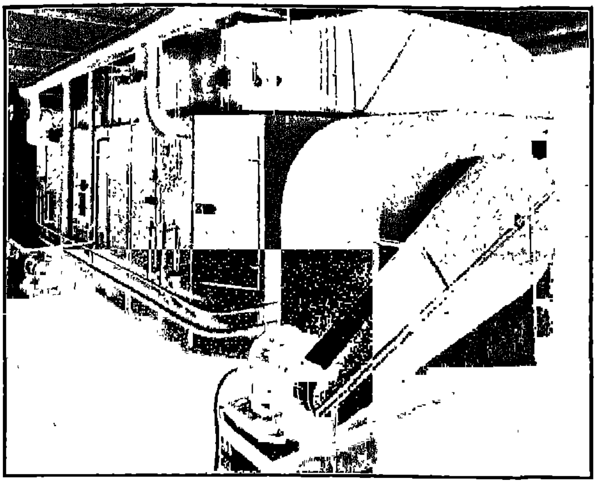
An air-conditioning unit. Follow the air from the time it enters at the right until it goes into the duct to be passed over the building. What happens to it?

How the Air Is Washed and Cleaned. Air is forced by powerful fans in the basement through a filter and then is washed in a spray of water. This combined filtering and spraying is said to remove 98 per cent of all germs and dirt from the air. These sprays not only wash the air, but automatically control its humidity, as it passes from the unit. If the weather is cold, the air is heated and then passes to the rooms at a temperature controlled by a thermostat. In hot weather, the air, instead of being heated, is cooled by refrigeration equipment while the constant temperature is again controlled by a thermostat. This equipment with various modifications illustrates the principle on which air conditioning works in large as well as small buildings.

Home Humidifiers. In the home open-window ventilation will, of course, give some humidity to the dry air of a furnace-heated house. We also get some water in the air from the evaporation which comes from water in basins, wash tubs, and bathrooms, as well as from growing plants, bowls or dishes of flowers, and home aquaria. But this sort of humidity is not always present. Shallow trays are made that fit over radiators or in back of them which allow for considerable evaporation of water but no home device is sufficient to give the amount of water (estimated at 6½ gallons a day for a six-room house) necessary for the proper circulation of moisture in the home. It would seem that some sort of air conditioning was necessary.

Ventilation of the School Plant. The problem of heating a public building is not as simple as that of heating our home. Not only do we have a large building to heat, but there are rooms used for so many different purposes, classrooms, library, assembly hall, study hall, laboratories, and the shops and gymnasium. In addition we have large numbers of pupils in some of the rooms,

and in other rooms, like the chemical laboratory and the shops, fumes and bad odors must be removed by proper ventilation. Since schools are generally closed during



A complete air-conditioning unit in a public building. In this the air is washed, humidified, heated, and driven out into the building by means of a fan.

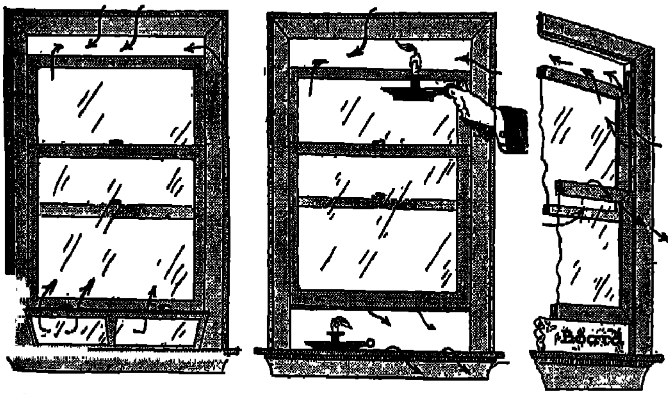
the hot season, we are not likely to find an air-cooling system installed for some time to come, but there is no good reason why the air should not be washed, humidified, and properly heated.

Artificial and Mechanical Heating and Ventilating Systems. In large buildings the heating and ventilating systems may be of three different types: (1) an exhaust or vacuum system in which air is drawn out of the rooms by means of fans after it has been heated and used; (2) the plenum system, in which heated air is forced into the rooms by fans; and (3) a combination system, which forces heated air into the room and draws used air out. In such systems indirect heating is usually used. The air comes in from the outside, passes over coils of steam pipes, and is passed to the rooms above. Most heating and ventilating systems for schools are still built to conform with an

idea now exploded, that enough air must be supplied to give each pupil 30 cubic feet of fresh air every minute. This was based on the belief that carbon dioxide was a poisonous gas that must be gotten rid of at all costs. Unfortunately, in heating systems just described, windows must be kept closed and no matter how hot the classroom gets, teachers must not open the window "because it interferes with the working of the heating system."

Recent Experiments in Heating and Ventilation. A large number of recent experiments made in schools have compared the health of pupils in schools having closed windows, with artificial ventilation and heating, with others having ventilation by fans but with windows open. It was found in two groups of children, each having over 1500 pupils of about the same age, sex, and parentage, that the mechanically heated and ventilated schools showed almost three times as many absences from colds and other diseases of the nose and throat as did the window-ventilated schools.

How Heating Is Accomplished in Window-Ventilated Schools. In such schools the best means of heating comes from placing radiators under the windows,



Apply these diagrams to the ventilation of your own bedroom. How would you prevent a draft there?

protecting them by shields so that they will not give too much heat off to those sitting near them, and by placing deflecting boards on the windows (shown on page 84) so that drafts are prevented. Air ducts are placed on the opposite side of the room from the window and fans pull out the used air. Open-window ventilation will not give the rooms 30 cubic feet of air per pupil per minute, but as we have already learned, that amount is not needed.

The Outdoor School. The ideal condition so far as ventilation is concerned is an outdoor school. But the temperature and weather in most places are so changeable that such schools are not widely used. The benefits from being out of doors come from sunlight as well as fresh air. In California during much of the year, the climate is so mild that many school buildings have rooms open on one side so that the effect is that of being in the open air. Children attending such schools are usually more free from colds than those in other schools.

SELF-TESTING EXERICSE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in numerical order. The same word may be used more than once.

less	proved	ideal	happy
uniform	home	30	moisture
temperature	surmised	minute	98.6
slowly	colder	more	school
rapidly	warmer	hour	heat
dust	adds	comfortable	rain
18	removes	evaporates	little

The drier the air, the (1)____ it must be kept in order to make us feel (2)____. This is because (3)____ (4)____ more (5)____ in dry air and so (6)____ heat. In air conditioning not only is (7)____ removed from the air, but the (8)____ and (9)____ are carefully regulated so as to maintain (10)____ conditions. It was formerly believed that every (11)____ room must be supplied with (12)____ cubic feet of air per pupil per (13)____. It has recently been (14)____ that that is (15)____ than is necessary.

ESSAY TEST

Robert Tells How Air Is Conditioned

Read carefully and critically. List all the errors and suggest corrections.

By air conditioning is meant changing the condition of air to one more favorable to man. This involves five possible changes. At times it needs to be warmed, and at other times it should be cooled. In the winter it generally needs to be dried, and often in the summer to be moistened. It often can be improved by filtering it to remove dust and carbon dioxide. With a high humidity a lower temperature is comfortable. Cold humid air about 45° F. is about as uncomfortable as hot humid air about 95° F. Evaporation of moisture from the skin is increased by a rise in both temperature and humidity. A spray of water is sometimes sent into a current of heated air which is sent through the ducts to the rooms of a house in order to increase the humidity of the air. A refrigerating unit in cooling moist air lowers its humidity.

THE REVIEW SUMMARY

In preparing a summary of what you have found out in this unit, you will want to place emphasis on the big ideas which have come from the applications of the facts you have learned and the demonstrations you have seen. Doubtless you have done some additional reading which has helped you put together some of the facts into generalizations or fundamental underlying principles. For this unit some of these generalizations are:

1. We breathe to secure oxygen to oxidize food and produce energy for the body.
2. Our air passages will remove a limited amount of impurities from the air; we must guard against excessive impurities and poisonous gases.
3. The amount of air required by law to be circulated through schoolrooms is in many cases greater than is necessary from a physiological standpoint.
4. Devices are now available for conditioning the air in the home.

Before making your review summary for your workbook, test your knowledge of the facts of the unit by checking over the text so

as to be sure you know the facts underlying the science principles or generalizations. Then using this material and everything you have read, seen, or done yourself, make your summary outline. This outline you may use when you make a recitation.

TEST ON FUNDAMENTAL CONCEPTS

In a vertical column under the heading CORRECT *write the numbers of all statements you believe are true. In another column under* INCORRECT *write the numbers of the false statements. Your grade = right answers* × 3⅓.

I. **Exhaled air differs from inhaled air in having:** (1) less oxygen; (2) less nitrogen; (3) less heat; (4) more carbon dioxide; (5) more water.

II. **Some of the oxygen taken into the lungs in breathing:** (6) is transported to the body cells; (7) changes the blood from red to blue; (8) is quickly exhaled; (9) becomes a part of carbon dioxide; (10) pushes the blood along.

III. **The air passages keep objectionable matter from the lungs in the following ways:** (11) moist surfaces catch the dust; (12) moving cilia expel foreign material from the air passages; (13) the large nasal cavity allows the air to rest and the dust to settle; (14) in the back of the throat the air is filtered; (15) in the larnyx there is a narrow slit through which only pure air can pass.

IV. **It is dangerous even for half a minute to breathe pure:** (16) oxygen; (17) carbon dioxide; (18) nitrogen; (19) carbon monoxide; (20) moist air.

V. **Frequently the air in the schoolroom may be improved by:** (21) opening windows; (22) increasing the carbon dioxide; (23) adding moisture to the air in winter; (24) increasing the humidity in summer when the relative humidity is only 70; (25) moving the air with an electric fan.

VI. **A modern air-conditioning plant will do these things to the air when desired:** (26) remove dust and germs; (27) add moisture; (28) remove moisture; (29) heat the air; (30) cool the air.

PRACTICAL PROBLEMS

1. What is a good way to increase your lung capacity?
2. Mary thinks that heat, carbon dioxide, and moisture are given off in breathing. How can she prove this?
3. With the heating equipment now installed in your home, how can you best increase the humidity of the air in your room in winter?

4. You come from an air-conditioned building where the temperature is 68° F. and the humidity is 55 out upon the street where the air is 95° F. and the humidity is 85. Explain the changes in physiological conditions of the body that result.

INTERESTING THINGS TO DO, READ ABOUT, OR SEE

1. Collect literature on air conditioning from manufacturers of equipment. Study this to learn the advantages each offers.
2. Visit the school heating and ventilating plant.
3. Breathing at high altitudes.
4. Read *Dust and Its Dangers*, by Prudden.
5. How I secure pure air in my bedroom.

SCIENCE FOR LEISURE TIME

1. Does Exercise Change Your Production of Carbon Dioxide?

Fill two one-liter flasks half full of clear limewater.

Test 1. After sitting quietly for five minutes, take a deep breath and exhale all you can through a glass tube so that your breath bubbles through the limewater. Cork the bottle and shake it.

Test 2. Exercise vigorously for five minutes, running upstairs and down, jumping, or exercising with dumbbells. Then quickly take a deep breath and blow through the other flask of limewater as before. Cork and shake the bottle.

Shake both flasks and compare the density of the white precipitate. The whiter the liquid, the more carbon dioxide. Do not use more than one breath because an excess of carbon dioxide will dissolve the white precipitate and make the milkiness less dense.

2. Make a Booklet of Clippings about Air Conditioning.

Section 1. Clippings of articles.

Section 2. Notes you have taken on articles you have read but could not clip.

Section 3. Advantages of air conditioning.

3. Survey of Sources of Impure Air.

Study your neighborhood. Note chimneys. How many give out black smoke at times? Are there barren sand areas where winds pick up soil particles? Are there grass and weeds that may give out pollens? Note especially if ragweed is plentiful, since that is one of the worst offenders in causing hay fever. Are the

streets clean? Are there factories or other places which produce offensive odors? Is there relatively much or little sickness in the neighborhood? Draw a conclusion based upon facts discovered regarding the purity of air in the neighborhood.

SCIENCE CLUB ACTIVITIES

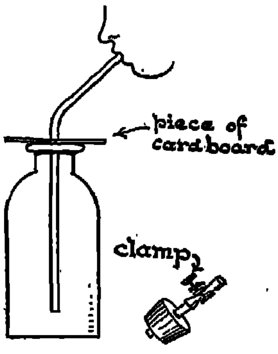
1. Lung-Capacity Contest.

Procure a one-gallon jug, four feet of large rubber tubing, twelve large glass tubes two inches long for mouthpieces, a six- or eight-quart pan, and hydrogen peroxide.

See who can displace the most water from the jug with a single breath. The normal lung capacity of an adult is about one gallon. Use the hydrogen peroxide to sterilize the mouthpieces after use.

2. Analysis of Respired Air.

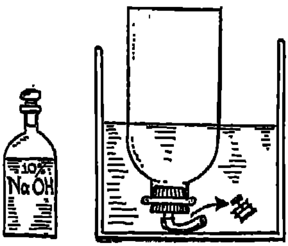
A bottle (8 oz.) is filled with the exhaled breath by blowing the breath through a large glass tube into the bottle, keeping the mouth of the bottle closed around the tube with the hand or with a piece of cardboard. Take a deep breath and exhale through the tube, drawing the tube slowly out of the bottle.



The stopper has a short glass tube running through it and joined to it on the outside is a rubber tube and clamp to close it. Close the bottle immediately after filling with the air from the lungs to be tested.

a. *Carbon Dioxide Test.*

A solution of sodium hydroxide will combine with the carbon dioxide and remove it from the air. Have 25 cc. of 10 per cent sodium hydroxide ready. Open the cork slightly and as quickly as possible pour all the sodium hydroxide solution in. Close the stopper tightly. Shake vigorously at first and repeat shaking occasionally for a period of five minutes. Then invert and tip the mouth of the bottle into a jar of water. Open the clamp. Raise or lower the bottle until the water in the jar and the liquid inside the bottle are at the same level.

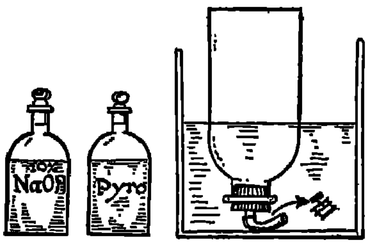


Close the clamp and remove the bottle. Open. Pour the liquid into a graduate and measure it. Measure the total content of the bottle up to the under side of the stopper. Make a table to record your figures.

Then calculate the volume of water which came into the bottle to replace the carbon dioxide removed by the sodium hydroxide. Calculate the per cent of carbon dioxide in this sample of respired air. Take into account the 25 cc. of solution added.

b. *Oxygen Test.*

The method of determining oxygen is like that for carbon dioxide except that pyrogallic acid is used to absorb the oxygen. Mix 25 cc. 10 per cent solution of pyrogallic acid with 25 cc. 10 per cent solution sodium hydroxide and add this mixture to the respired air. The carbon dioxide will be absorbed as before, but in addition the oxygen will be absorbed. In this case the water that comes in will represent what two volumes? Work out your own system of tabulation and method of calculating the per cent of oxygen in respired air. Records. Calculations. Results. Conclusion.



c. *Crude Nitrogen.*

The remainder of the air is chiefly nitrogen. But the other constituents of air including water vapor are of course mixed with it. What is the per cent of this crude nitrogen?

3. Make a survey of buildings in your community and have a meeting devoted to a description of different kinds of ventilation observed in different buildings. Especially note buildings that have air-conditioning units. Make a chart or map for exhibition purposes showing the kind of ventilation systems found in (*a*) factories, (*b*) auditoriums, (*c*) churches, (*d*) schools, (*e*) other public buildings.

4. Plan a demonstration to be put on before the science class showing the best methods of cleaning a room: Use feather duster, dry broom, damp broom, carpet sweeper, vacuum cleaner, moist cloth. Test your results with a series of sterile Petri dishes containing culture media. Have an exhibit showing your results.

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Survey Questions

Can you explain the cause of a spring? a well? a river? a lake?

How can pure water be supplied to a city?

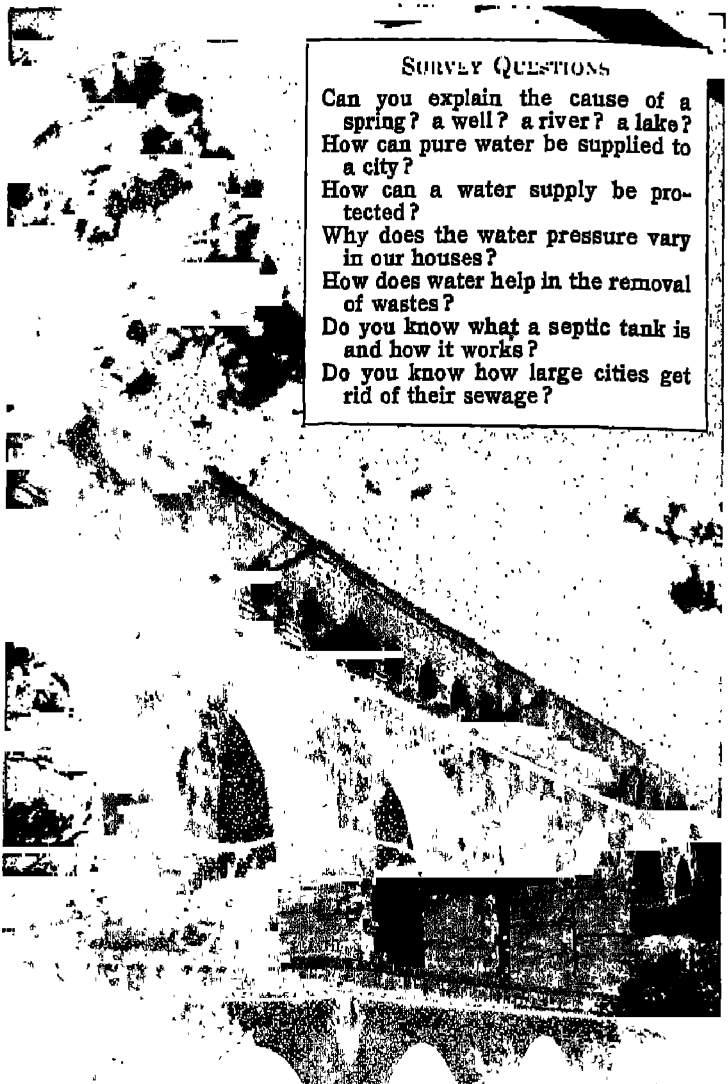
How can a water supply be protected?

Why does the water pressure vary in our houses?

How does water help in the removal of wastes?

Do you know what a septic tank is and how it works?

Do you know how large cities get rid of their sewage?



Olive Garrison, R. I. Nesmith and Associates

UNIT IV

A CITIZEN'S NEED OF WATER

PREVIEW

Water has always been a chief need of mankind. The earliest men must have established their rude shelters close to a source of fresh water. We have every reason to believe that in the cities of ancient civilizations, water was one of the chief factors which decided their location. The Greeks and Romans went to great trouble and expense to get good water, building long aqueducts to bring it to their cities. As discoverers and pioneers pressed on to found new settlements, these were always made close to streams of pure water.

When the Pilgrims landed near the site of Plymouth, they looked for a suitable place to settle. An old journal tells us that Captain Miles Standish and his party "marched into ye land and found there cornfields and little running brooks, a place fit for a situation"; and so, with little running brooks for their first water supply, they founded their first community. In our early communities people used to get their water from shallow wells which were not always sufficient for the needs of the town. In the early days of New Amsterdam, fresh water was peddled from home to home, because the well water in lower Manhattan was neither good nor plentiful.

As more and more people came to live together and towns became larger, it became necessary for homes to be supplied with water that was not spoiled by filth from the homes of neighbors, so water systems and sewerage

systems came into being. Then, with the development of machines and factories, still new ways of using water came and a larger supply was necessary. Water was needed to make steam to run engines, to make chemicals, to wash fabrics, to use in hundreds of ways. Think of it, in early times a gallon a day for a person was considered a large amount, while now 150 gallons a day per person is the allowance for New York City. Water makes possible the trees in our parks and yards and the plants in our gardens. Water has long been used as a useful agent in fighting fire.

The story of obtaining and protecting a modern city water supply is an interesting one. Cities nowadays build aqueducts ten times the length of those built by Romans, as we see in the Los Angeles aqueduct, which

Brown Bros.

The Los Angeles aqueduct crosses deserts, tunnels mountains, and goes under deep canyons by means of inverted siphons.

A tunnel 13 miles in length is being constructed under San Jacinto Mountain as a part of the new Colorado River aqueduct in southern California.

brings water 250 miles from the Owens Valley to the city, and is even now being extended to take supplies many miles farther away. Mountains are tunneled, rivers are crossed by great inverted siphons, such as the one under the Hudson River. Huge dams hundreds of feet in length form great artificial lakes, such as that at Ashokan in New York or the great Hetch-Hetchy Lake from which San Francisco gets its water supply. Southern California's need for water is so great that it will soon be carried over deserts and through mountains, 241 miles from the Colorado River to the terminal reservoir near Los Angeles. In this project there are 84 miles of tunnels 16 feet in diameter, one of which, the San Jacinto tunnel, pierces a mountain nearly 11,000 feet in height for a distance of 13 miles; and another will form an almost continuous tunnel 33 miles long, making one of the longest tunnels in the

world. Cities have come to use immense amounts of water, over 180 gallons a day per person being no unusual allowance for some large cities. This does not mean that each person uses that much water, but it does mean that the city uses this amount in putting out fires, cleaning the streets, running the factories, and in a hundred other ways for its daily work. This unit will help us understand the way in which modern cities and towns get their water supply and use it in their homes. Before beginning your serious study of this unit you should see how much you remember about water, that you learned in a similar unit in your science course last year. You want to build on a firm foundation of facts and principles. You cannot do this unless you recall the essentials, which are the following:

Science Principles

1. Water is found in these states — solid, liquid, and gas — and produces many important changes on the earth.
2. Water is a chemical compound which can be separated into two elements, hydrogen and oxygen.
3. The natural changes of water on the earth — to vapor, clouds, rain, and back to water — make up the water cycle.
4. Many living things are adapted for life in the water.
5. Living things cannot exist long without water.

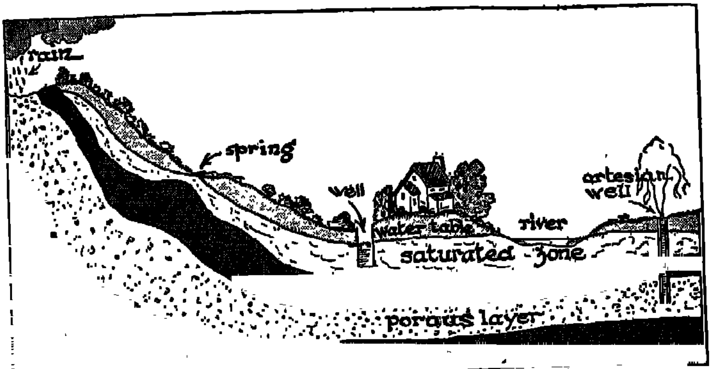
PROBLEM I. WHAT ARE THE SOURCES OF WATER?

Water Is Everywhere about Us. Water is found almost everywhere in nature. If you bore into the ground, you sooner or later come to water. In the air you find it as vapor, and on humid days the air is almost saturated with it. You find it as fog, in clouds, as rain, as ice, as hail, dew, and frost. It bubbles out of hot springs, or gushes forth as geysers in the Yellowstone. It runs out in the

form of cold springs or as artesian wells in some parts of the country. You have already seen that it makes up a large part of plants and animals. It is not hard to find water in nature.

Rain Water Is Pure. The purest natural water is rain water as it falls from the clouds. In many parts of the world, such as Bermuda, people use rain water, as they have no other source. The best way to collect such water is to have the water falling on the roofs run into cisterns underground. The first water during a rain should be diverted from the cistern so that dust and impurities on the roof may run off.

Ground Water and Where It Comes From. We all know that after a rain much of the water runs off and finds its way into streams. Some of it evaporates into the air, but a good deal finds its way down between the tiny grains of soil until it comes to a solid layer of impervious material through which it cannot soak. This may be a layer of clay, hardpan, or bed rock. Above this layer is formed a sheet of water-soaked soil through which the water flows slowly, following the general level of the impervious layer. If this layer tilts upward, then the



Point out the upper limit of underground water. What is it called? Why would we have a well at one point and an artesian well at another place?

underground stream will make a sort of pool. The surface of water in the ground is called the water table. All the water from below the earth's surface is called ground water, and is the source of our water in wells, springs, and artesian wells.

Springs and Wells. It is evident that when we dig a shallow well, we go down below the surface of the saturated zone of water. If the saturated zone reaches the surface of the ground, it may make a running spring, especially if on a side hill. But if on a level stretch of ground, it makes a swamp. On hillsides in the country you frequently see spring houses which protect the water supply for the homes below.

When water enters porous ground at a high level between two layers of impervious material, it will travel long distances between them. If we bore through the upper impervious layer into the underground water at a level much below its origin, the water will shoot out under

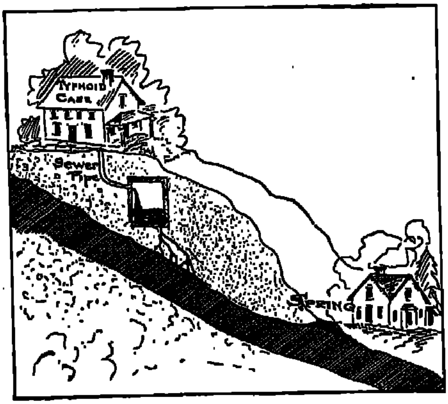
National Park Service

What are the differences between geysers and artesian wells?

pressure into the air. This is called an artesian well. Underground waters frequently contain mineral matter which they have dissolved from the soil through which they have passed. The world-famous springs at Saratoga or Vichy in France are of this nature.

What Is Impure Water? We usually consider water pure unless it contains something that is injurious to health. Ordinary dirt or mud found in water will not cause illness unless there is decaying organic matter in it. Wherever we find decay, we find germs which cause this decay, so impure water, from a health standpoint, is water containing germs. When we realize that germs of different kinds exist in the food tube of our body, and that the wastes which are passed off are full of germs, then it is evident that water which contains sewage is impure. Any water drawn from the surface of the land would be more likely to contain such wastes, and hence would be more dangerous than water coming from underground.

Safe Wells and Deadly Ones. Many of us who have visited the country on our vacations remember with pleasure the cold water from the deep well or hillside springs near the farmhouse. Look at the picture and see how a spring may be polluted by a cesspool. We have all doubtless seen places where the well water might be a source of danger, for all the wastes from the house sinks, from the barnyard, and from the privy or cesspool might soak



A spring located like this one is deadly. Are there any such in your locality?

into the well and render it impure. Could you really determine a safe place for a well without knowing something of the rock and soil under the house and grounds? Drainage from the soil may mean that impurities reach the well. We must also protect the well from surface drainage. A concrete parapet which slopes away from the opening of the well will protect the water in the well. If one is uncertain as to the purity of the water, a sample can be sent to the town or state bacteriologist, to determine whether the water is safe to drink. This should be done in any case where you suspect that the water is not pure. A *driven well* on a slight elevation, when the pipe is driven deep into the soil and situated at least 100 feet from a cesspool or barnyard, will, in ordinary sandy soil, give pure water. This makes a particularly safe well.

Courtesy Matson-Ocean Line

What is the source of this glacier? How do you account for the black lines on each side of the ice sheet? What will you find at the foot of the glacier?

Glaciers as a Source of Water. Have you ever been on a glacier? If so, you will never forget the experience of climbing out on this great slow-flowing river of ice. At its foot you saw a great mass of ground-up rock which it had brought down from higher up on the mountain, and if you found the lowest point under the glacier, you saw a stream of water rushing out bearing with it a great quantity of tiny ground-up particles of rock and soil which gave it a muddy appearance. Glaciers are the sources of many rivers. In some parts of the world, for example in the areas surrounding the poles, such as Greenland, we find great caps of solid ice covering the land to a great depth. It is estimated that 1,000,000,000 tons of ice pass off or slide down from the ice cap covering Greenland each year. This ice breaks off from the foot of the glacier to become icebergs which gradually melt as they flow southward, thus releasing water which is evaporated in the warmer regions.

Water in Rivers, Lakes, and Oceans. The waters from springs, from glaciers, and especially from surface run-off make their way down hill into depressions where rivers, ponds, and lakes are formed. Eventually water from these bodies finds its way into the ocean. Rivers, ponds, and lakes are all sources of public water supplies. The ocean water, because of its salt content, cannot be used for this purpose unless it is distilled.

SELF-TESTING EXERCISE

Select from the following list those words which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

rocks	vaporized	rain	surface
ground	evaporates	lake	streams
quartz	air	soaks	spring
roots	clouds	swamp	spaces
evaporation	porous	impervious	well
saturation	table	water	saturated

The purest natural water is (1)____ water. When rain falls to the earth some of it (2)____ going back into the (3)____; some of it runs off into the (4)____ and lakes and a very large part of it (5)____ into the (6)____. Water in the soil will eventually reach a layer of (7)____ material and then will fill the (8)____ between the soil particles above it. This produces a (9)____ zone whose surface is called the (10)____ (11)____. A (12)____ is formed by digging down below the water table. A (13)____ is formed when the water table reaches the surface of the ground on a hillside and a (14)____ results when this occurs on level ground. In order to have conditions to produce an artesian well there must be two (15)____ layers with (16)____ soil between and this layer must at some place come to the (17)____ where (18)____ can enter it.

ESSAY TEST

Ada Tells Us We All Drink Rain Water

Read carefully and critically. List all the errors and suggest corrections.

You have all read that the people in Bermuda drink rain water, but I shall try to prove to you that you drink rain water, too. Your city supply may come from a lake, a pond, or a river. What are these bodies of water? They are only storage reservoirs for the rain which falls into them. A pond or lake may have a river outlet or a river may run into a lake or pond, but whichever way it is the water all fell directly from the clouds into these bodies of water. If you get your water from a spring or a well, you are still drinking rain water. The earth is a natural filter and removes the many impurities the rain gets while passing through the air. Sand does not dissolve in water, as you can see when waves wash up on the shore, and so the filtered rain water in wells and springs does not have anything in it that is not rain water. This is why well and spring waters are so pure.

PROBLEM II. HOW DO WE GET WATER INTO OUR HOMES?

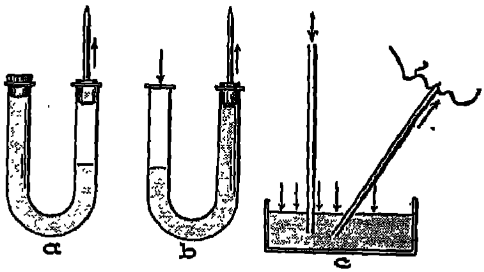
If you live in the city, the problem of getting water into your home is not a difficult one for you. All you have to do is turn on a faucet and the water comes out. But have you ever thought how that water got into your home? Sometimes the source of the water is very many miles

distant from your home and it may have traveled from its source far up in the mountains through pipes into storage reservoirs, there to remain until other pipes deliver it to our homes. Or it may pass into standpipes so that it may flow, under pressure, downhill into our homes. But if you live in the country, in many instances it becomes necessary to pump the water from a lower source up into the house. Let us see how this is done.

Demonstration 1. To See if Atmospheric Pressure Can Lift Water.

Materials. U-tube, solid stopper, a piston made by fitting a spike tightly into a rubber stopper, glass tube, and a vessel of water.

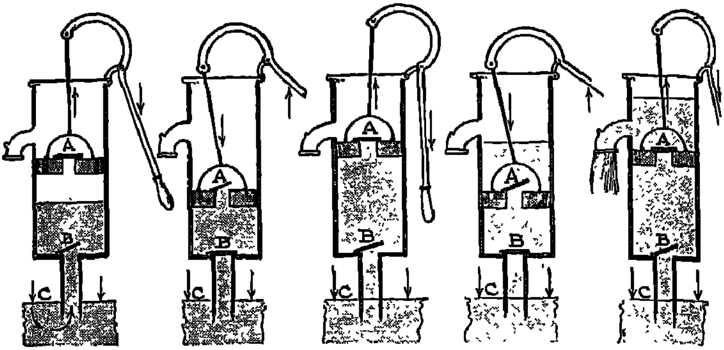
Method. (*a*) Fill the U-tube with water. Push piston three quarters of the way down one side of the tube. Place the stopper in the other end. Pull the piston to the top of the tube. (*b*) Repeat (*a*) but leave the end of the U-tube open. (*c*) Place one end of a straight tube in a jar of water. Suck the air out from the open end.



Observations. What happens in (*a*) and (*b*)? What force is allowed to act in (*b*) but not in (*a*)? Does water rise in the straight tube before you suck through it?

Conclusion. Give all the reasons you can to prove that atmospheric pressure lifts water.

How the Lift Pump Works. We have already seen that air exerts pressure. Let us now apply this principle of air pressure to the lift pump. The tube of the lift pump extends down into the well or cistern. The upper part (see diagram) has a piston containing a valve (*A*). Another valve (*B*) is placed at the top of the tube just where it enters the barrel of the pump. Both of these valves are hinged and are pushed open by a force from below. A force on top tends to close them. When the



Explain what is taking place in each of these five diagrams of the lift pump.

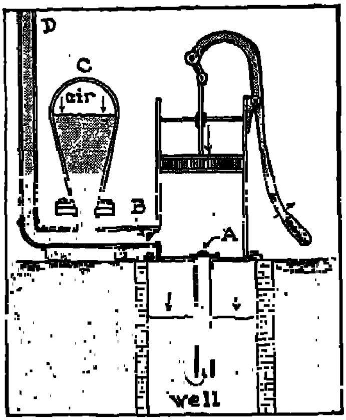
piston is raised, the air pressure is reduced on top of valve *B* so air from below pushes up through *B*, and the pressure on the water inside the pump is decreased. Water is pushed into the tube by air pressing down on the surface of the water in the well or cistern. This pressure you remember is nearly 15 pounds to the square inch. We take a few short rapid strokes and this brings the water up so that it fills the space above valve *B*, and when the piston is pushed down into the water, valve *A* in the piston is forced open and water rushes into the space above it. On the next upward movement of the piston, the water is lifted higher so that it flows out of the pump. You may remember that Galileo and Torricelli found that a pump would not lift water much more than 33 feet because the air pressure will not balance a column of water higher than this. As a matter of fact, the lift pump will not raise water more than about 28 feet because of leaky valves and piston.

The Force Pump. We know, however, that water can be taken out of wells much deeper than 28 feet. This may be done by means of a force pump. In this pump a piston moves up and down in the barrel of the pump. At the lower end of the barrel is an inlet valve *A* and at

EVANGELISTA TORRICELLI, 1608-1647.

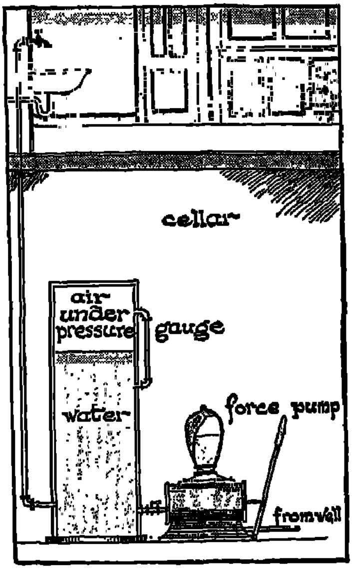
WE always associate the name of Torricelli with that of Galileo, although the latter was a blind old man when the former was just beginning his studies. Torricelli must have been a bright boy with much interest in mathematics and we hear of him while still a youth studying mathematics under a famous teacher who had been a friend and student of Galileo's. It was probably through his teacher that he went to help the blind Galileo prepare his last great work for publication. And it was probably because he had shown his great ability in mathematics that Torricelli was appointed as Galileo's successor as professor of philosophy and mathematics in the University of Florence.

While Galileo was still alive he had noticed that a suction pump would only lift water to a height of about 34 feet, and he must have put Torricelli at work trying to see why this was. They decided that the water was held to this height by air pressure. Eventually, he and his assistant named Vivian got the idea of using a denser substance than water and experimented with mercury. They found that air would support a column of mercury about 30 inches high. Out of this experiment came our useful instrument, the barometer.



Explain how this pump is capable of delivering water to a height of more than 28 feet.

the side an *outlet* value *B*. (See diagram.) Connected with the pipe leading from the outlet pipe is an air dome *C* in which the water may compress air. If there is no air chamber, the water delivered through pipe *D* will flow only on the down stroke of the piston. But when the air dome is used, the air compressed in *C* will force the water through *D* on the upstroke of the piston also. This makes a more uniform flow of water. The force pump can lift water to any desired height, but the pump must be placed so that the valves are not over 28 feet above the surface of the water.



A pneumatic tank. Explain how the air is put under pressure and what this compressed air can do.

The Pneumatic Tank System. It is found that whenever a confined gas is reduced to half its volume, its pressure is doubled. Therefore in some homes where it is necessary to raise the water some distance, a pneumatic tank is used. When such a tank is three-quarters full of water, the air is compressed to one quarter its original volume, and the pressure then becomes four

times that of the atmosphere. Since one atmosphere equals 15 pounds to the square inch, four atmospheres equal 60 pounds pressure to the square inch. But to run from the faucet, water must overcome the push of the air or one atmosphere. This reduces the resultant pressure to 45 pounds per square inch. If the pressure of one atmosphere can lift water 33 feet, how high can a pressure of three atmospheres lift water?

SELF-TESTING EXERCISE

Select from the following list those words which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

lever	down	pneumatic
pump	up	air
raise or lift	raised	pushed
weight or pressure	lowered	heavy
34	feet	force
15	28	weight

Water can be raised in pumps because air has (1)____. When the piston of a pump is (2)____, water fills the space below it because it is (3)____ (4)____ by the (5)____ pressing on the surface of the water in the well. A lift pump will (6)____ water about (7)____ (8)____, but by using a (9)____ pump alone or in connection with a (10)____ tank, water can be lifted higher.

ESSAY TEST

Brainerd Reports on the Water System in His Home

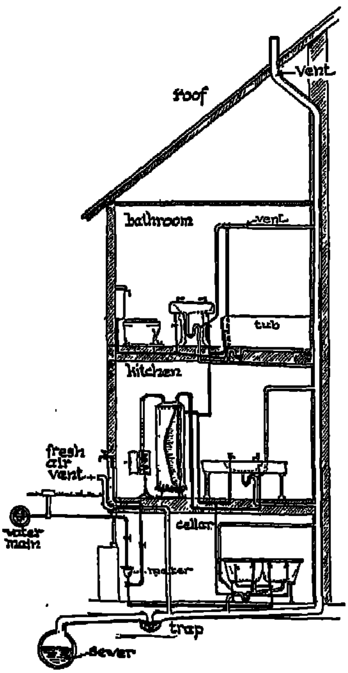
Read carefully and critically. List all the errors and suggest corrections.

I live on the outskirts of the city. We have a well 60 feet deep. A force pump is placed in an inclosure 25 feet above the water. An electric motor operates the pump. The inlet pipe extends into the water. The well must be inclosed air-tight to keep off the atmospheric pressure. The discharge pipe enters a pneumatic tank in the cellar. When the water gage on the tank shows it is $\frac{3}{4}$ full of water the inclosed air is pressing down on the water with a force of 45 pounds per square inch. This is due to the fact that

we bring the atmosphere and the water together and thus add the pressure of the atmosphere — 15 pounds per square inch — to the pressure in the tank. The discharge of water from the tank is jerky instead of an even flow: this is because the tank is supplied by a force pump.

PROBLEM III. HOW DO WE USE AND CONTROL WATER IN THE HOME?

We have already seen that we use water for drinking, cooking, and washing. It is also necessary for flushing toilets and getting rid of other wastes. It is used in hot-water boilers for heating our houses either by steam, hot water, or water vapor, and of course is necessary for the lives of our plants and animals which live in and around the home.

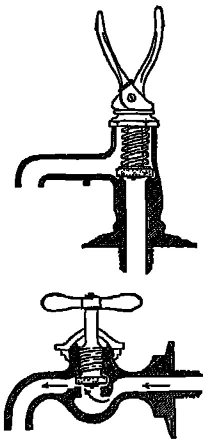


Trace a drop of water from the time it leaves the water main until it reaches the sewer. Through what parts of the plumbing might it pass?

Sanitary Plumbing. The word *plumbing* includes pipes, faucets, and traps through which water is carried in the house. The Latin word from which plumbing comes means *lead*. Lead pipe has been used extensively for carrying water and is still used, though brass and iron pipe have become much more common in modern plumbing.

Faucets. In order to obtain water when we wish it, and to check its flow at other times, a device called a *faucet* is necessary. If you study diagrams, you will see that there are two types: one having a handle which

screws down a washer over an opening, thus shutting off the flow of water, and another type in which the pressure of a spring holds the washer down so that no water can get out. When the handles are squeezed together, the pressure is released and the water flows through. Every boy and girl should know how to stop a faucet from leaking. The first thing is to turn off the supply of water at the shut-off valve, then take off the handle of the faucet with a wrench and remove the washer. A new washer, which can be bought at any hardware store, should then be put in, and the handle replaced. Sometimes a faucet gives a knocking noise which is due to vibrations when water passes through it. If this noise is caused by a loose washer, it may easily be fixed, but if due to worn threads it will need to be replaced. Leaky faucets waste water and consequently money. Do not allow them in your home.



What newer modifications of these faucets have you seen?

Service Pipes. A service pipe brings water in from the outside street main. Water usually passes into a water meter situated in the basement where the amount of water is measured. The water meter has a valve for shutting off the water in case of accident, and for draining the pipe when repairs have to be made.

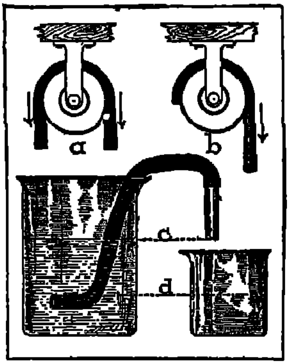
In order to get water and wastes out of the house, a system of drain pipes is necessary. A vent pipe extends from cellar to roof and is connected to the drain pipes: its purpose is to carry off odors and prevent sewer gases from entering the house. The drain pipes must leave the house at a point lower than any other place, for outlet pipes must run slightly down hill.

The Siphon and Its Uses. The siphon is used in several plumbing devices as traps, flush tanks, and toilets. Let us see how it works.

Demonstration 2. To Understand the Working of the Siphon.

Materials. Battery jar, glass beaker, rubber tube, glass tube, pulley with little friction, cord or rope to go over pulley.

Method. (*A*) Hang a short heavy cord or small rope over the pulley, leaving the two ends at the same level. (See figure *a*.) Change cord so that one end hangs six inches lower than the other side. See figure *b*. What happens? (*B*) Connect a six-inch length of glass tubing to one end of rubber tube. Fill the glass and rubber tubes entirely full of water. Hold one finger over the end of glass tube and put the end of rubber tube into a jar of water. Hold the end of the glass tube just below the level of the water in the jar. Take your finger from the end of the tube. What happens? Now raise the tube until the end is just level with the water on the surface of the jar. What happens? Lower the end of glass tube so that it is several inches below the level of the water in the jar. What happens? What will happen if the outside end of the tube is raised above the level of the water in the jar?

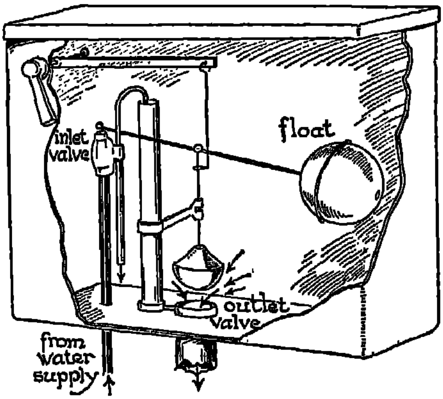


Conclusion. The tube is used in this experiment as a siphon. Explain how much of the action of the siphon depends upon the pressure of the atmosphere. Why is it necessary to fill the tube with water to start the action of the siphon? How does the analogy with the rope help to explain a part of the action of the siphon?

The siphon is a device that carries water over an elevation and delivers it at a level lower than its source. We make use of it when we draw gasoline from the automobile tank, and in the traps of the plumbing system. To start a siphon it is always necessary to fill the tube with liquid.

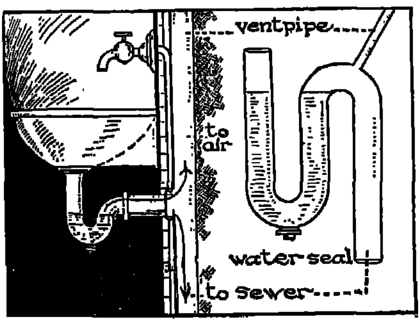
Flush Tank. Examine the diagram of the flush tank which is used above toilets. Notice that when the toilet

is flushed, the surface of the water is lowered; that the ball float opens a valve which allows a new supply of water to come into the tank. When the water reaches a certain level, the float automatically closes the valve. We flush the toilet by pulling a lever which opens the outlet valve, and water passes through the flush pipe. The valve is light in weight and remains raised until the surface of the water gets down to it. After losing the lifting force of the water, the valve closes. The tank then fills up as has been shown previously.



Explain how this flush tank works. What is the position of the ball float when the tank is full? When it is empty?

Traps. In order to prevent odors and sewer gases from getting into the house, fixtures known as traps are necessary. Under the kitchen sink is a grease trap, but in other places the S trap is used. These traps shown in the diagram have a water seal formed by the use of an inverted siphon. In order that the water may not siphon out of the trap, it is a common practice to join the top of the upward bend in the trap to the vent pipe. If



Why is this called a water seal?

this is not done, most of the water will be drawn off and evaporation might remove enough to allow gases from the sewer to come back into the house.

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

water	stands	lead	brass
screw	lower	pipes	float
flow	higher	filling	flows
upper	valve	vent	faucet
draining	types	filled	spring

The plumbing system in a house refers largely to (1)____ through which water (2)____. Formerly (3)____ pipe was used to a greater extent. It is largely replaced today by (4)____ and iron. In order to get a liquid to flow through a siphon it must first be (5)____ with the liquid and the outlet must be (6)____ than the inlet. The flush tank is kept from running over by a (7)____ controlled by a (8)____. S traps should be connected to the (9)____ pipe to prevent them from (10)____. Water is carried to a particular place through (11)____ and regulated by (12)____ of the (13)____ or (14)____ type. Much waste of (15)____ results from leaking (16)____.

ESSAY TEST

Pauline Looks Over the Plumbing System

Read carefully and critically. List all the errors and suggest corrections.

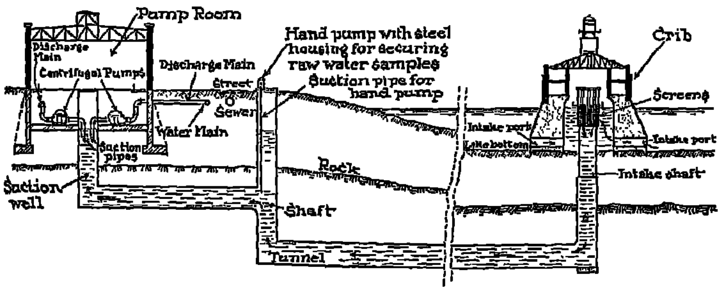
I have just completed a survey of the plumbing system in my home. I found the service water pipe entering the cellar; near it was a meter and a valve to shut off the water. There are many pipes near the cellar ceiling I never saw before. Upstairs I find no pipes except short connections. It must have been lots of work to take up floors and open walls to put the pipes in there where I am told the pipes are. The faucets are good except one which doesn't shut tightly enough to prevent a small stream continually running. But this was of no consequence as it was at the wash tub in the basement. I think the pipe leading off from the kitchen sink must be too small because it takes a long time for dish water

to run out. I understand the reason lead pipe is used more than iron for the water pipe is that iron is harder than lead and the iron makes the water hard. Hard water is not suitable for washing.

PROBLEM IV. HOW DO CITIES PROVIDE SAFE WATER FOR THEIR CITIZENS?

The problem of getting safe water for a city is a serious one. Not only must the water be plentiful at all seasons of the year, but its source ought to be high enough so that gravity will bring the water easily into tall city buildings. Then, too, the water should be reasonably safe to drink. Unfortunately not all cities are placed so that they get a pure water supply. Some cities such as Buffalo, Cleveland, and Chicago take their supply from lakes on which they are located and into which some sewage drains. Others such as Philadelphia, St. Louis, Pittsburgh, and Cincinnati must draw their supply from rivers which contain a great deal of sewage coming in from small towns and cities located above the point at which the water is taken. Another type of water supply is seen in New York, Los Angeles, and San Francisco. These cities have no near source of pure water and tap supplies far from the city in order to get an abundance of pure water.

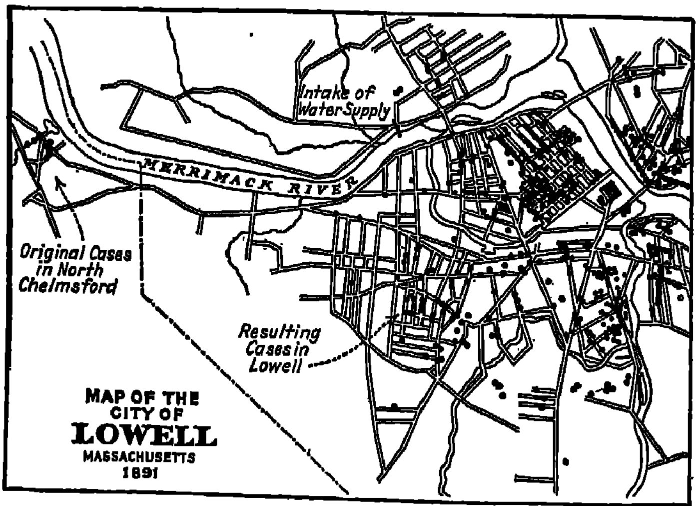
Lake Supplies. Chicago, Cleveland, and other large cities near lakes draw their water supplies from the lake



Follow a drop of water from the time it enters the intake of a Chicago crib to the time it reaches a home. The water is chlorinated just before it enters the mains.

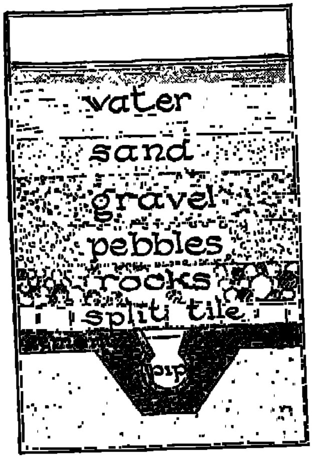
at a sufficient distance from the shore so that the water is not contaminated with sewage. The city of Chicago has built cribs for the taking in of water several miles out in the lake. Here lake water flows through a screen into an intake shaft and tunnel which runs shoreward to pumps which force it into the mains all over the city. The water is chlorinated before it reaches the mains. Before the Chicago drainage canal was built (see page 126), the death rate from typhoid fever was very high because much sewage found its way into the water supply. Today typhoid fever has practically disappeared, thanks to the drainage canal and to the additional safety gained through chlorination of the water supply.

River Supplies. An interesting story is that of the first understanding of the relation of polluted water supplies to certain diseases. In 1891 a very serious



Lowell was formerly supplied with unfiltered water from the Merrimack River. In 1891 several cases of typhoid fever occurred in North Chelmsford and then Lowell had an epidemic. Explain why this happened. (Each dot represents a case of typhoid.) This epidemic resulted in the first filtration of a city water supply in this country.

outbreak of typhoid fever occurred in the cities of Lowell and Lawrence, Massachusetts. The city of Lowell took its water supply without filtering it from the Merrimack River a few miles above the city. Typhoid fever broke out in the little town of North Chelmsford a few miles above Lowell. About two weeks later a very severe epidemic of typhoid broke out in Lowell and about a month later a similar epidemic, though not quite so severe, occurred in Lawrence, some 10 miles farther down the Merrimack River. What had happened was this. Typhoid germs from North Chelmsford sewage passed into the river and into the Lowell water supply. People drank the water and along with it the germs of typhoid. They sickened with fever, and the germs from their bodies passed out in the sewage and were taken in by people in Lawrence. This story has been repeated for a great many years by almost every city and town which took its water from similar sources.

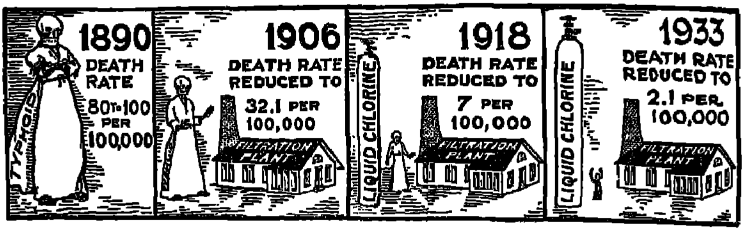


A vertical section of a filter bed. Refer to your text to see how it is used.

The First Use of the Filter Beds. Allen Hazen, a water expert, with a group of other scientists showed that the outbreak at Lowell was caused by drinking unfiltered water. Filter beds of sand were installed through which the water slowly trickled, and by means of these beds about 98 per cent of the germs were taken out. In this way water which was unfit to drink was made quite safe. This plan, worked out over 40 years ago at Lowell, is now used with certain improvements in every city that has to take its water from rivers or lakes that contain sewage. The

filter bed usually consists of small stones, gravel, coarse sand, and fine sand in layers as seen in the diagram. In order to make a filter plant fit for service, a number of beds must be available, so that each one may be taken out of service after a few days of use, the sand removed, sterilized, and the bed thoroughly cleaned.

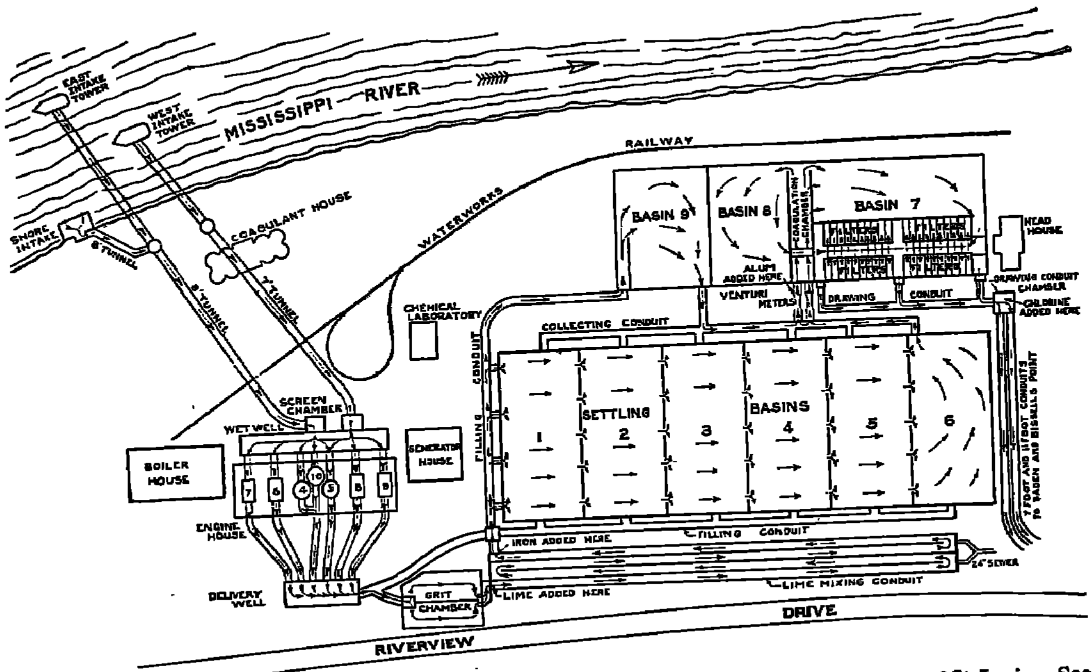
Use of Chlorine. Although filtering removes most of the germs, it has been found that the use of bleaching



How the death rate has been reduced in one midwestern city. The last results are in part due to coagulation before filtration and chlorination.

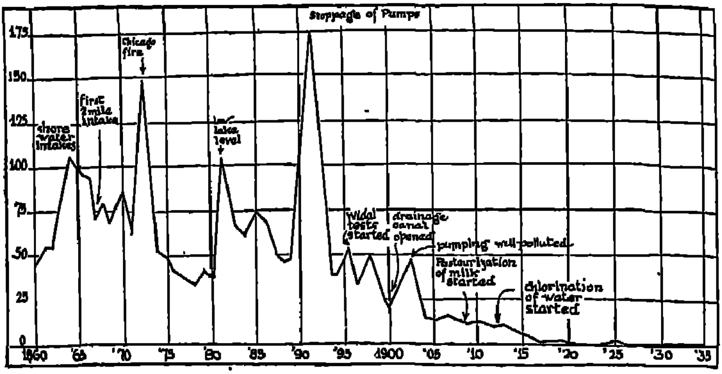
powder or liquid chlorine will kill practically all the germs that are left after filtering. Modern city plants use chlorine in the way shown in the illustration.

Modern Filtration Systems. St. Louis and Kansas City have to take their water from the muddy Mississippi and Missouri rivers, respectively. In addition to having sewage, these waters also contain a great amount of mud which must be removed before filtering. The city of St. Louis first pumps water into great settling basins which have a capacity of over 2,000,000,000 gallons. Here the water is treated with chemicals which help settle the mud. After about 34 hours, the water is passed into filtration beds in which are rapid sand filters. Just before the water goes through these filters it is treated with sulphate of aluminum. This causes a jelly-like solid to form which catches most of the bacteria. Rapid sand filters soon become clogged and have to be cleaned about every 24 hours. This is done by reversing the flow of



A diagram that shows the operation of the Chain of Rocks purification and pumping plant for the city of St. Louis. See if you can follow the course of the water from the time it enters the intake tunnel until it reaches the conduits that take it to the distributing reservoirs.

water through the beds, thus washing out the dirt and bacteria, which are sent into a sewer. After filtration, water has liquid chlorine added to it. This kills all the



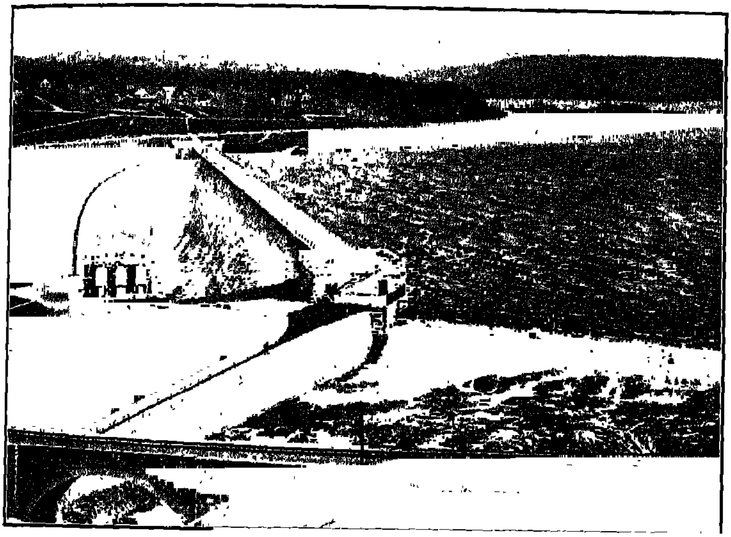
Typhoid in Chicago. What relation have these events had to this disease?

bacteria that may be left and renders the water fit for drinking. St. Louis with a population of over 800,000 uses about 140 gallons a day per person. The filtration plants are able to deliver about 3,000,000,000 gallons a day for the city's water needs, more than twice the amount the city normally uses.

The filtration and chlorination of this water supply has changed completely the death rate for certain diseases. In 1849, St. Louis had an epidemic of cholera which killed nearly one eighth of its total population. Cholera is a disease which is passed from one person to another in drinking water. As late as 1892, it had 105 deaths per 100,000 persons from typhoid. In 1903, this rate dropped to 47 per 100,000; in 1917, it was 17 per 100,000; in 1923, when both filtration and chlorination were used, it dropped to 4.2 per 100,000 and is around 2 per 100,000 today. In other large cities where filtration and chlorination have been used similar improvement has been made.

Water Supply of New York. The city of New York formerly took its water from the Croton watershed, an

area about 40 miles from New York. In this watershed huge reservoirs were constructed, and by means of an aqueduct New York was supplied with about 500,000,000 gallons of water a day. But as the city grew in size it became necessary to get more water. Consequently, the city purchased an area of about 900 square miles of mountainous land in the Catskill Mountains. Here they constructed at great expense two great reservoirs at Ashokan and Schoharie. To make these reservoirs possible and to secure pure water, it was necessary to move several villages and numerous houses, as well as some thirty-five cemeteries. The Schoharie watershed flows away from New York, so, in order to bring the water back

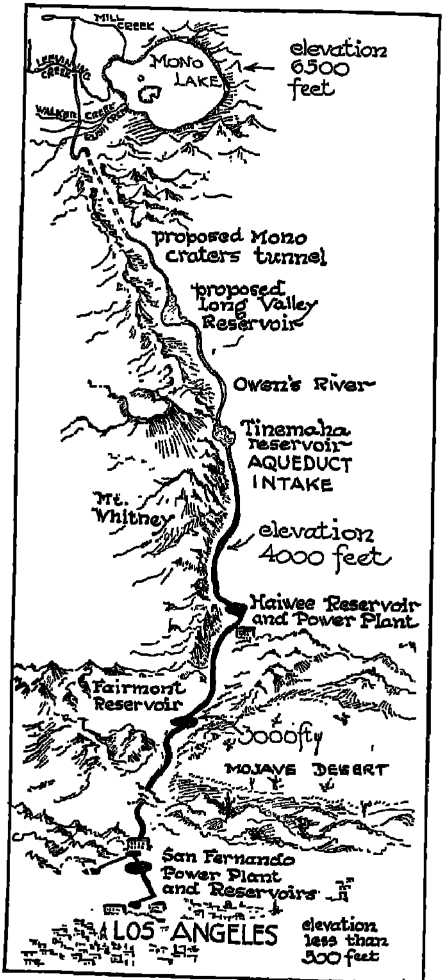


Water Division, Boston, Mass.

Large reservoirs help purify water as well as store it. This is one that supplies the city of Boston.

to New York, a great tunnel was made under the Catskill Mountains. This system supplies over a billion gallons a day to the city of New York. In addition to the huge

storage reservoirs, distributing reservoirs were made at Kensico, and at other points not far from the city line. Here the water is treated by means of great fountains. This allows the water to dissolve oxygen which helps to remove bad tastes and odors, as well as to kill bacteria.



Los Angeles is planning to tap a new source of water supply now flowing into Mono Lake. Trace the new aqueduct on a good map.

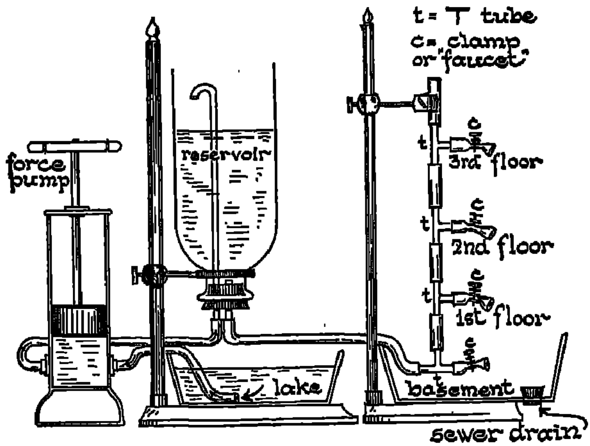
Los Angeles Water Supply. Los Angeles gets water by means of a great aqueduct which runs 250 miles over desert and mountain to the source of the Owens River, a stream fed by the glaciers of the Sierra Nevada range. In this aqueduct water comes down from a high altitude and develops great pressure on its way. At certain points along the way the water passes through turbines which generate electricity, thus making the water serve a double purpose for the people of Los Angeles, who get cheap electric power as well as pure water.

San Francisco Water Supply. Although San Francisco is surrounded by water, it has never had an adequate supply until recently. But in 1934, after over twenty years of planning and labor, water from the Hetch Hetchy Valley, 156 miles away, was piped into the city. A great artificial lake holds back the water which flows through 87 miles of tunnel, and 69 miles of steel flumes, into the receiving reservoirs near the city. This great project has cost San Francisco over $100,000,000.

The Use of Reservoirs. Storage of water in reservoirs is additional protection to the water supply. Bacteria can live in open bodies of water only for a short time because of the action of the air and sunlight, both of which kill them. In some large reservoirs, algae grow and may give the water an unpleasant taste. One of these plants, called *Synura,* got into one of the reservoirs of New York not so many years ago and produced such a fishy smell that people were afraid to drink the water. This little plant can be removed by adding copper sulphate.

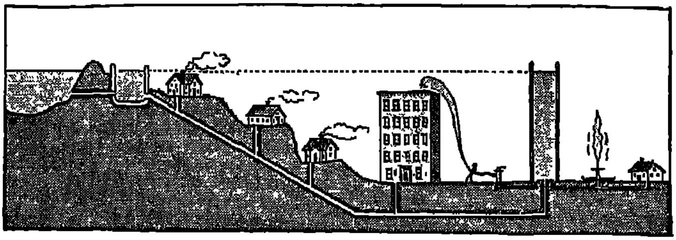
Demonstration 3. Effect of Water Pressure on Flow from Faucets.

Set up apparatus as shown in the diagram using a force pump to fill the reservoir. The reservoir or stand pipe shown by the



bottle marked "reservoir" can be filled from the pan marked "lake" and the tube leading into the bottle closed by means of a clamp. Now unscrew clamps on 1st floor and 3rd floor. Any differences in force of flow? Fill the bottle a second time and open 2nd floor and basement faucets. Any difference? Which of the four faucets has the strongest flow? How do you account for this?

It is desirable to have the reservoir at such an elevation that water may flow by gravity and reach the tops of the tallest buildings it supplies. By opening the "faucets" one after the other in the demonstration apparatus, it will be seen that the pressure is least on the top floor.

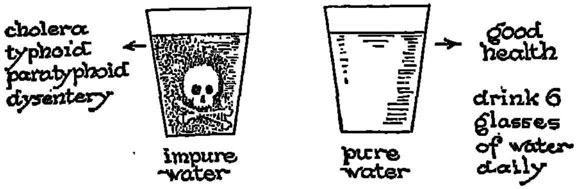


In this diagram a stand pipe is used as well as a reservoir. What law does this diagram illustrate?

Sometimes it is necessary to pump water into tanks on the roofs of houses to obtain a good flow of water on all floors. In many parts of the central West where the ground is flat and water comes from underground sources, cities have tall stand pipes, with tanks at the top so as to give the necessary water pressure for tall buildings.

Protection of Water Supplies. When a city obtains its water from an area which is populated, it becomes necessary to maintain a force of sanitary police to prevent violation of laws for the protection of the watershed. When using a public watershed we should remember, first, never to injure public property. The cost of repairs is a large item of expense, and this is especially true in the upkeep of hydrants, water pipes, and reservoirs. Second, we should protect public watersheds from pollution,

always clean up rubbish and material that might decay after a picnic, and use only public toilets when in parks or



Water affects the general health of a community.

near watersheds. Third, we should take the utmost care when fishing or camping not to pollute the water. Fourth, we should report to the health authorities the breaking of any rules of sanitation by any person. Fifth, we should be careful about drinking water which we are not sure of. All drinking water from unknown sources should be boiled.

Relation of Water Supplies to Health. We know that water is directly concerned with certain diseases. Cholera, typhoid fever, paratyphoid, dysentery, and perhaps some other diseases may be passed on through drinking water. The general health of people in a community, however, seems to be affected by the water they drink. It has been found that where water supplies are poor, the general health of the citizens is poor. They seem to be predisposed to other diseases. Pure water, then, is an asset which should be guarded by every citizen.

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

air	cold	nitrogen	sewage
water	bacteria	chlorine	cotton
food	algae	cancer	sedimentation
shelter	sand	filters	scarlet fever
sunlight	mud	typhoid	tuberculosis

Water in rivers or lakes may become polluted from (1)____ in (2)____. Such water can be made safe for drinking by passing it through (3)____ (4)____ and treating it with (5)____ to kill the (6)____ that pass through the (7)____. The death rate from (8)____ has been greatly reduced by these measures. Some germs in water are killed through lack of (9)____ and from the action of (10)____ and (11)____.

ESSAY TEST

RITA RECEIVES NEW IDEAS ABOUT THE WATER SUPPLY

Read carefully and critically. List all the errors and suggest corrections.

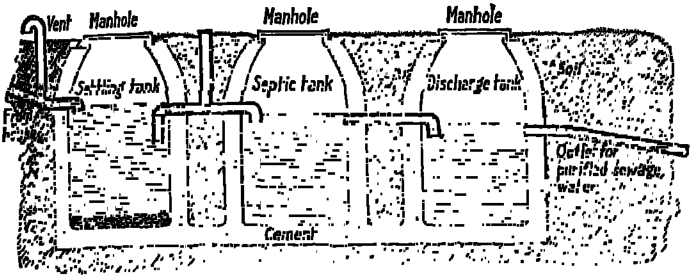
I never dreamed so many things had to be done to the water before it comes to our faucets. Typhoid fever germs may be delivered in our water supply if it is not treated with chlorine. But chlorine itself is a poison. Science has progressed so that today people can be treated with a serum which makes them immune to typhoid fever. I think it would be much better to omit the chlorine treatment which gives the water a chemical flavor and to inoculate the people with antityphoid serum. It would be cheaper too because the immunity lasts for years. If I lived in a city that had sewer pipes to carry off the household wastes, a well in the yard or even in the cellar would give pure water for household uses. I would not like to live in Los Angeles where the water comes a long distance and on its way gives up much of its energy to produce electricity. Such water, having lost so much energy, must be very weakening to a person drinking it.

PROBLEM V. HOW DOES WATER HELP IN THE REMOVAL OF WASTE?

Disposal of Sewage. Many country homes have a cesspool in the form of a deep hole in the earth, having an open bottom, uncemented rock or brick walls, and a covered top. This receives sewage from the house which drains out gradually into the surrounding soil. While this works fairly well in sandy soils, cesspools cause a good deal of trouble in clayey soils and have to be cleaned out frequently.

Septic Tank. A far better way to dispose of sewage is by means of a septic tank. It has been discovered that

two types of bacteria cause decay, one of which (anaërobic) thrives without air, obtaining oxygen from the sub-



What happens to the household wastes in this septic tank to make them harmless?

stances on which they feed. The other bacteria (aërobic) must have air in order to live. A septic tank is usually built with three compartments, all made of cement and all water-tight. Sewage flows from the house into the first compartment and, after fats and other substances rise to the surface, an air-tight scum is formed under which the anaërobic bacteria in the sewage work. They thus cause the solid materials in the tank to become liquid. As the sewage is broken down or decomposed, it passes into the second tank where still more decomposition takes place, this time caused by aërobic bacteria. The contents of this tank pass into a third tank from which the contents are siphoned off into tiled drains under the ground. Here soil bacteria act on the sewage, rendering it quite harmless, so that the fluid may be used for irrigation purposes.

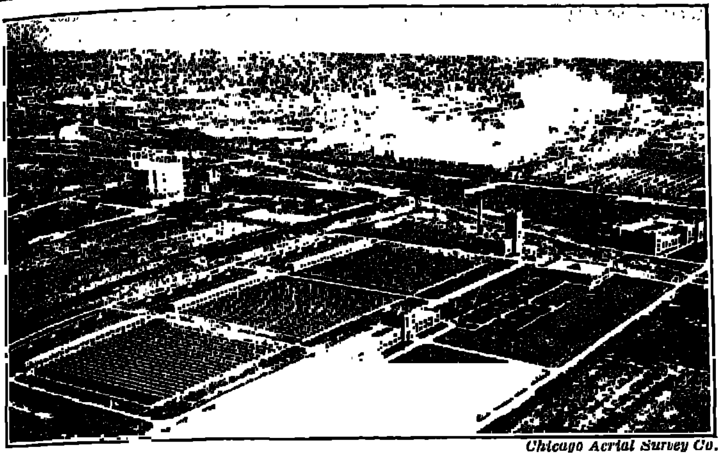
Sewers and Their Uses. Sewers or drains to carry off water and wastes have been used since the times of the Romans. Sewage consists of body and household wastes diluted in water. In flowing rivers a small amount of sewage may be carried off without harm since bacteria of decay found in the rivers break down solid materials into harmless liquid substances. But in all large cities, the disposal of sewage is a serious problem. The city of

New York empties daily almost 1,000,000,000 gallons of sewage into the rivers and ocean, thus bathing Manhattan Island in diluted sewage. Fortunately, here the ebb and flow of the tides carries off so much of this material that it is not a serious menace to health. At the present time work has been started on a sewage-disposal plant on Wards Island which, when completed, will care for about 200,000,000 gallons of sewage a day, the first unit of a complete sewage-disposal system. Until 1900 Chicago discharged its sewage directly into Lake Michigan, and as a result many cases of typhoid occurred in the city because bacteria found their way into the water-supply intake of the city two miles off shore. Chicago then built, at a cost of $40,000,000, a drainage canal which draws the waters of Lake Michigan *out* into the Chicago River and then into the Des Plaines and Illinois rivers. Through this canal the sewage of Chicago, diluted with Lake Michigan water, passes. While this was good for Chicago, it was rather hard for the people who lived on the Des Plaines and

The Chicago drainage canal. What are the present advantages and disadvantages of this canal?

Illinois rivers, for those rivers became open sewers. There have been many complaints and lawsuits over the disposal of this sewage, and Chicago has been forced to

treat a part of it and will eventually have to treat it all in order to be fair to the people living on these rivers.



Chicago Aerial Survey Co.

A new sewage treatment plant of the city of Chicago. Over $41,000,000 has been allotted by the P. W. A. to build several of these plants.

Other Methods of Sewage Disposal. When the sewage cannot be run directly into a body of water, it must be passed to a disposal plant. Here by means of septic tanks, filter beds, mechanical and chemical treatment the solid wastes can be removed and the liquid sewage transformed into a comparatively harmless and odorless liquid. In some parts of California, sewage from small cities is thus treated and is then used for irrigating fruit trees and other crops. The latest method of treating sewage uses air and constant agitation of the liquid to increase the action of the bacteria. This "activated sludge process" is being used in a number of cities. Chicago in 1928 put into operation the largest plant of this type in the world. The liquid portion of the sewage is thoroughly chlorinated before being passed into the canal, while more solid matter is sent to open-air drying beds. After drying, this waste material may be used as fertilizer. Many cities are now required by law to treat

their sewage before disposing it in streams. Unfortunately, waste from factories, stock yards, and gas plants may do much damage to plants and animals living in streams. To conserve the fish there, we must have them protected. In many parts of the country, various organizations are now actively fighting poor methods of sewage disposal.

Garbage. In the country, garbage can be buried, burned, and some of it fed to farm animals. In the cities, household wastes must be collected or disposed of in incinerators, which are devices for drying and burning. In many communities covered carts are used to collect garbage, which may be fed to hogs, burned, or sent to garbage-disposal plants where curiously enough some of the wastes are made into soap and perfumes, while other materials are made into fertilizers. The city of New York for many years has taken its garbage to sea in scows and dumped it there, only to have much of it returned to the beaches which were the city playgrounds. Huge incinerators have recently been installed which destroy the garbage at a moderate cost. In time all the garbage of greater New York will thus be disposed of.

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

different	river	well	disposed
cess	harm	ocean	source
treat	wasted	wastes	pollute
septic	treatment	pollutes	disposal
filters	filtration	water	sewer
air	lake	same	remove

Sewers are pipe lines constructed so as to (1)____ (2)____ from homes and conduct them to a place where they may be (3)____ of without (4)____ to people. Sewage (5)____ is a serious problem

for large cities, because such wastes may (6)____ the (7)____ of (8)____ supplies for other cities. A city (9)____ its own (10)____ supply if it takes water from a (11)____ and passes its sewage into the same (12)____ without proper (13)____. Sewage is rendered harmless by (14)____ tanks, chemical (15)____, and sand (16)____.

ESSAY TEST

Hugh Presents His Notes on Disposal of Wastes

Read carefully and critically. List all the errors and suggest corrections.

If I lived in a city which had no piped sewage system, I would choose to have a cesspool because this is cheapest and gives the least trouble. Some people have septic tanks, but they must be very unhealthful because they can have no ventilation. The bacteria which are useful in septic tanks die in the presence of air. The removal of wastes by running water in sewage systems is a modern invention. Sewage systems are wasteful and many large cities in countries such as China today save all these waste materials and use them to fertilize crops. For years New York has dumped its garbage a few miles off shore into the ocean. Much of this washed back upon the beaches in New Jersey. Of course nothing can be done to prevent this action. The government has no power to say what shall be done in the open ocean beyond three miles from shore and nobody can prevent the action of wind, waves, and tides.

THE REVIEW SUMMARY

In preparing a summary of what you have found out in this unit, you will want to place emphasis on the big ideas which have come from the applications of the facts you have learned and the demonstrations you have seen. Doubtless you have done some additional reading which has helped you put together some of the facts into generalizations or fundamental underlying principles. For this unit some of these generalizations are:

1. Water is abundant on the earth, except in some desert areas.
2. Gravity is used in getting water into our houses.
3. Compressed air can lift water to the tops of our buildings.

4. Water is controlled in our houses by a system of pipes and valves.

5. Water removes wastes.

6. Cities provide pure water by filtration and chemical treatment of water from natural sources.

Before making your review summary for your workbook, test your knowledge of the facts of the unit by checking over the text so as to be sure you know the facts underlying the science principles or generalizations. Then using this material and everything you have read, seen, or done yourself, make your summary outline. This outline you may use when you make a recitation.

TEST ON FUNDAMENTAL CONCEPTS

In a vertical column under the heading CORRECT *write numbers of all statements you believe to be true. In another column under* INCORRECT *write the numbers of the false statements. Your grade = right answers* $\times 2\frac{1}{2}$.

I. **Water from a deep well or spring usually:** (1) has much sediment in it; (2) has some dissolved minerals in it; (3) is the home of water animals; (4) is safe for drinking; (5) tastes flat or insipid.

II. **Water is safe to drink if it has been:** (6) freshly distilled; (7) filtered through five layers of cotton cloth; (8) boiled 20 minutes; (9) frozen and then melted; (10) taken from a rapidly flowing river.

III. **A suction or lift pump cannot raise water to a high level without the help of:** (11) two valves; (12) a pump spout; (13) atmospheric pressure; (14) a vacuum in the well; (15) some outside force to operate the piston.

IV. **Traps in the plumbing system:** (16) make it possible to save things lost down the drain; (17) keep foul gases from coming back into the house; (18) are used to save the grease that would otherwise be carried into the sewer; (19) improve the appearance of open plumbing; (20) may need cleaning to allow water to flow freely.

V. **Water from a river may be made safe for drinking by:** (21) using a filtration plant; (22) filtering it and treating it with chlorine; (23) boiling it; (24) putting it under pressure; (25) examining it under the microscope to see if it contains bacteria.

VI. **Sewage may be satisfactorily disposed of by:** (26) letting it run into a near-by river above a water supply; (27) chemical treatment; (28) extending sewer pipes out into the ocean where people bathe; (29) septic tanks; (30) cesspools if the soil is mostly clay.

VII. **In order to secure safe water a city may:** (31) use the water from a near-by river just above the city; (32) have people use filters on their faucets; (33) treat the water with chlorine; (34) get its water from a distant protected watershed; (35) depend on local springs and wells.

VIII. **The advantage of a force pump is that it:** (36) works independently of atmospheric pressure; (37) will carry water to any desired height; (38) may be operated by hand or by motor; (39) requires no valves; (40) delivers a steady stream of water without the use of compressed air.

PRACTICAL PROBLEMS

1. The water in your well is of doubtful purity. You have no other source of water. How will you make it safe to use?
2. Suppose you have purchased woodland on a lake in an uninhabited region and want to build a camp for summer use. Tell how you will proceed to determine what will be the best way for you to (1) provide a water supply and (2) get rid of waste.
3. Two neighbors A and B have wells about 15 feet apart. The boundary line of their land comes between the two wells. In a severe "dry spell" the water gets lower and lower until A's well is dry. There is still some water in B's well and A asks to be allowed to get water there. But B refuses to allow this because he fears there will not be water enough for both families. There is no other source of water within a mile. Thereupon A digs his well 10 feet deeper and gets an abundant supply of water, but at the same time B's well becomes dry. Can you explain why B's well became dry? Do you think B will be allowed to get water in A's well? Ought A to invite B to get his water from the new well? What would you do if you were A? if you were B?
4. You are going to try to fix a leaking faucet. Tell just what you will do.

INTERESTING THINGS TO DO, READ ABOUT, OR SEE

1. A new water-supply development.
2. Story of the travels of a molecule of water.
3. My homemade water filter.
4. An interview with the plumber.
5. Different ways water is used in preparing foods.
6. How spots and stains can be removed from clothing.
7. Soap making.
8. Report on a popular science book I have read.

SCIENCE FOR LEISURE TIME

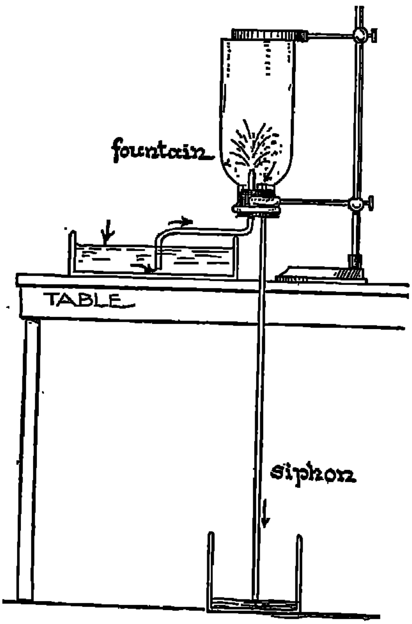
1. A Carbon Dioxide Pop

Soda water is water charged with carbon dioxide under pressure. When the bottles are closed with corks, the loosening of the cork allows the compressed gas to blow it out with a resulting "pop." Hence the name "pop" for the soft drinks. You can duplicate the popping action by producing carbon dioxide in a closed bottle as follows. Place a heaping teaspoonful of baking powder in a heavy walled soda water bottle. Pour in 1 ounce of water and instantly press a cork stopper in tightly. You will not wait long for results. A piece of dry ice may be substituted for the baking powder if available. If you do this at the house protect the ceiling by holding a box above the stopper.

2. Make a "Squirt Gun"

Fit a piston to move inside a light-walled metal tube, about 8″ to 10″ long and $\frac{1}{2}$″ to $\frac{3}{4}$″ in diameter. Plug one end tightly with a piece of wood. Drill a hole through this with a $\frac{1}{32}$″ or a $\frac{1}{16}$″ drill. You should be able to use this without further directions.

3. Make a collection of pictures of different devices used to move or control water or operated by water.



4. Secure from some friend information about the city water system, sewer system, or the use of water by the fire department.

SCIENCE CLUB ACTIVITIES

1. Prepare for a *Siphon Program.* Each member of the club will try to bring in the longest list of uses of the siphon. Have various types of siphons — glass, rubber, and self-starting siphons. Arrange for several demonstrations. Have reports on regular and inverted siphons in large water-supply systems. One suggestion for a novel

demonstration is that of an automatic siphon-fountain suggested in the diagram. Have a pint of water in the bottle at the start. The lower the receiving tank is below the reservoir the greater the vacuum and thus the greater the force in the fountain.

2. Another good program is a *Pump Program*. Members bring in working models of lift pumps and force pumps they have made. These may be demonstrated and explained.

3. A visit to the pumping station or purification plant of the city water supply will be enjoyable, full of interest, and will give you valuable information.

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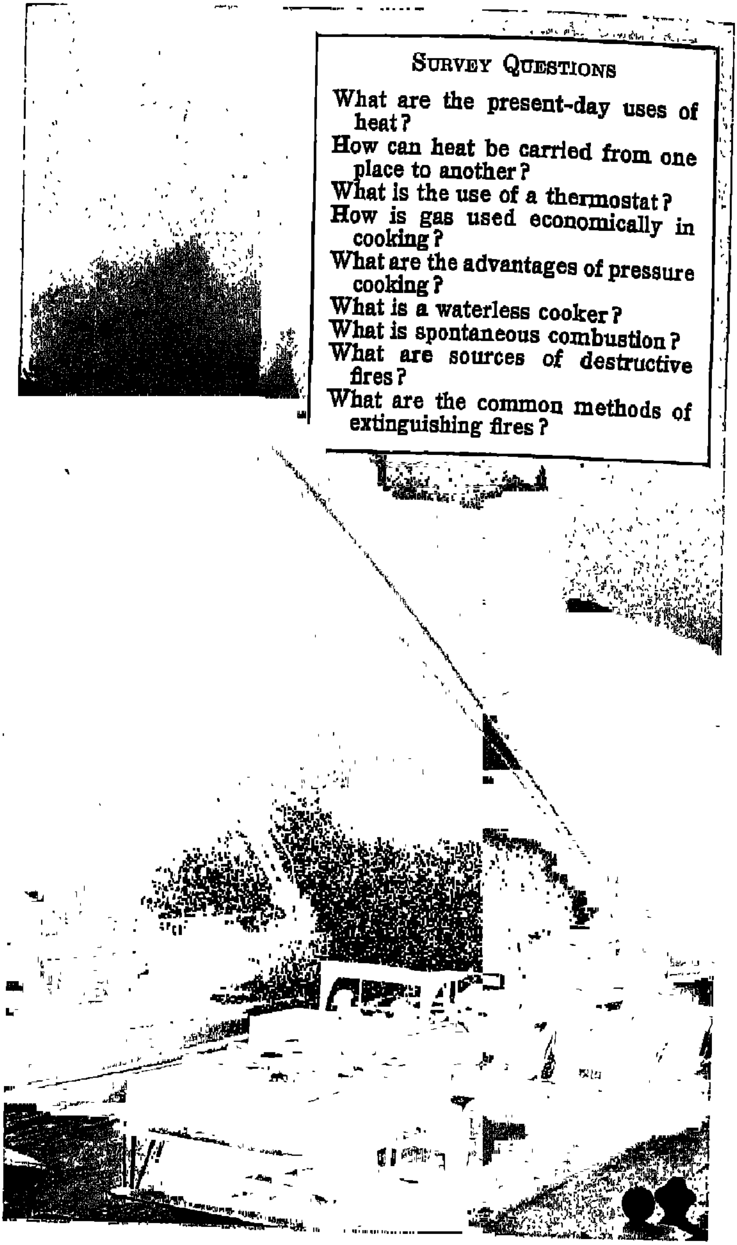


Survey Questions

What are the present-day uses of heat?

How can heat be carried from one place to another?

What is the use of a thermostat?

How is gas used economically in cooking?

What are the advantages of pressure cooking?

What is a waterless cooker?

What is spontaneous combustion?

What are sources of destructive fires?

What are the common methods of extinguishing fires?

UNIT V

HOW HEAT IS USED IN HOME AND COMMUNITY

PREVIEW

We can only guess how heat was used in the earliest primitive homes. Perhaps early man discovered a hot spring, perhaps lightning set fire to a tree and he discovered the value of fire from this, perhaps he may have struck a spark by knocking two hard stones together. At any rate heat was used very early and soon became a necessity for both cooking and warmth. The Romans used fire for heating their baths and homes. Great fires were built in rooms underneath the home, and the hot air, fumes, and gases were conducted up to warm the living room. Earliest homes were heated by fires built in the middle of the room, the smoke escaping through the roof. Later the fire was removed to the side of the house and a chimney built to carry off the smoke. Fireplaces came into use in the fifteenth century. Not much improvement was made until about 1742 when Benjamin Franklin invented a stove. This was a decided advance, for it not only saved fuel, but it radiated heat from the iron of which it was made. Then came the heating systems. First the stove was moved out of the fireplace, then the "drum" or enlargement was placed over the smoke pipe and made to heat rooms above. Then furnaces came into use through which hot air was sent to different rooms. These were followed by steam, water vapor, and combinations of the two. The latest devices not only heat the homes, but clean the air and moisten or humidify it

so that it will be fit to use. All this is done by an automatic control. With the building of great apartment houses and public buildings, heat has to be carried for some distance. We often find central heating plants in cities from which the heat stored in steam is conducted in well-insulated pipes underground to many buildings. A few scattered towns in different parts of the country make use of hot springs from which hot water is piped around the town for the purpose of heating. Where natural gas is abundant, heating of buildings is often done by the unit system where different parts of the building may be heated by small separate heaters. This is a very practical way where the climate is not very severe. Electricity is used for heating where water power is abundant and electricity cheap.

But with our heating systems and greater use of fire has come more danger. The greater fire hazards come from longer flues, higher chimneys, and greater use of fuels, especially oil and gas. The carelessness of smokers plays an important part in fire. The annual fire losses in homes and communities in this country have been nearly $500,000,000 a year for the past ten years. This unit will help us to find some ways to do our part in lessening fire hazards and controlling fire as it is now used.

Before beginning a serious study of this unit, you should see how much you remember of what you learned about heat last year. You want to build your science on a strong foundation of science principles. The following are those on which this unit is based:

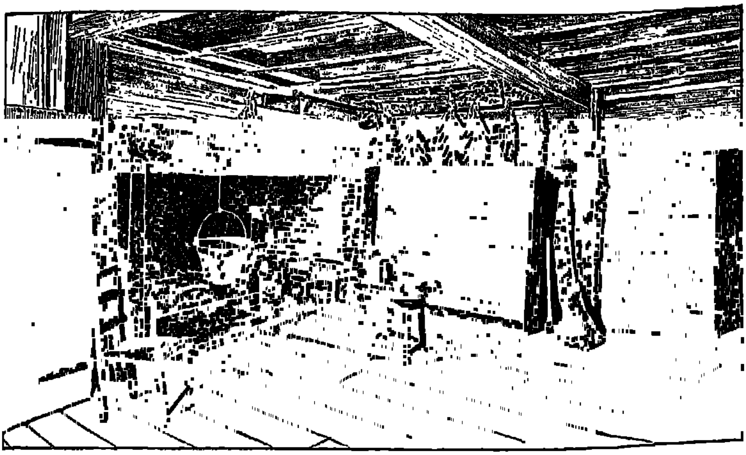
Science Principles

1. Heat is present in all matter.
2. The amount of heat in matter can be changed.
3. Heat can be transferred from one body to another.

4. Heat is produced from other forms of energy and in turn can produce other forms of energy.
5. Heat causes many changes in matter.

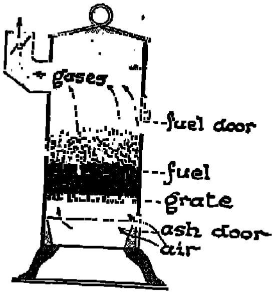
PROBLEM I. HOW ARE OUR HOMES HEATED?

How a Fireplace Works. As you know, a fireplace is like a large box with brick or stone walls on all sides except for one opening into the room and another into the chimney. When a fire is built, cool air comes into the fireplace from the room and pushes the hot smoke up the chimney, thus causing what we call a draft. Much more air passes through the fireplace and out the chimney than is needed to burn the fuel. The burning fuel and the hot walls of the fireplace radiate heat into the room. This radiant heat is absorbed by furniture and walls of the room. Air must be constantly supplied to the room, usually through cracks around doors and windows. Thus there is fresh air in a room warmed by a fireplace. In colonial days fireplaces were the chief sources of heat both for warming the room and for cooking. But today,



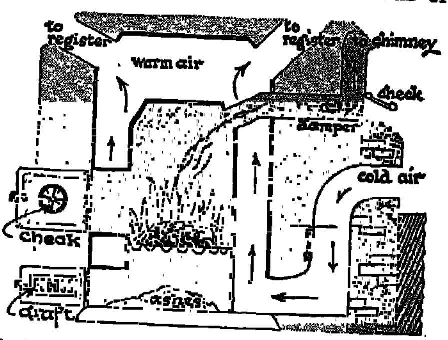
A fireplace of colonial times. Why do you suppose such a wide fireplace was used?

because we have more economical heating devices, the fireplace is not in common use.



Where are the air controls of this stove? How would you use these to check the fire?

How a Room Is Warmed by a Stove. In order to save much of the heat which escapes out of the chimney from the fireplace, an inclosed fireplace, called a stove, is set up in the room and connected to the chimney by a smoke pipe. Air coming in contact with the hot surface of the stove expands, becomes lighter, and is pushed up by the heavier and colder air which takes its place. These warm currents of air are cooled as they pass by the windows and cold walls, and they sink again to the floor. The stove gives off into the room by convection and radiation about seventy to eighty per cent of the heat obtained from the fuel. Since the stove is warmer than other objects in the room, it radiates heat to them; heat is also brought through the metal from the inside to the outside surface of the stove by conduction. Thus all three methods of heat transference are used to some extent in heating a room.



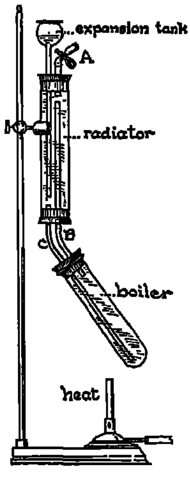
Explain the two independent systems of convection in this warm-air furnace.

The Warm-Air Furnace. The warm-air furnace is simply a large central stove placed in the cellar, and covered with a much larger metal jacket,

from the top of which metal tubes, or ducts, lead out to the different rooms that are to be heated. Fresh air is brought to the bottom of the space between the fire box and the inclosing jacket, and, as it becomes hot, is pushed up and passes through the pipes to the various rooms.

Regulation of Fire. In starting a fire, the lower draft and the damper should be open, but the check draft should be closed. Why? By opening the check draft, partially closing the damper, and closing the draft, the fire will burn slowly. Why? By closing the damper completely, the air current is checked and burning almost stops. If the room is overheated, close the draft and the check in the stovepipe and open the damper and the fuel door. The air from the room will then pass over the coal and up the chimney, thus cooling the stove or furnace without helping the materials to burn.

When the check in the smoke pipe is open and the damper closed, air from the outside passes into the smoke pipe and out the chimney. This reduces the current of air through the fuel and so checks the fire. In checking the fire, always close the draft, for otherwise the poisonous gas, carbon monoxide, may escape into the room. A very small percentage of this gas in the air is fatal.



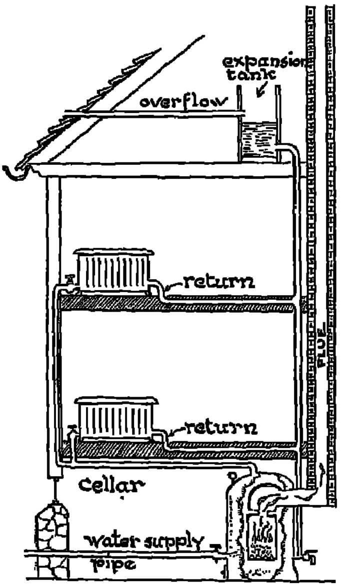
Demonstration 1. To Show the Principle of Hot-water Heating.

Set up the apparatus shown in the diagram. Open the clamp A (air valve on radiator) and pour water into the expansion tank. When the boiler and radiator are full, close A. Drop a few small crystals of potassium permanganate to the bottom of the radiator through the thistle tube (expansion tank).

Apply heat gently at first to the middle portion of the test tube (boiler). Watch the tubes between boiler and radiator. The colored water will show if there is any move-

ment of water. After one or two minutes feel *C* and *B*. What does this indicate? A little later feel of the bottom and top of the radiator. Explain result. Make a diagram for your workbook and insert arrows to show how the water circulates and tell how this demonstration explains the process of hot-water heating in a house.

The Hot-water Heating System. In the hot-water heating system, we have a combined furnace and boiler in the cellar, radiators in the rooms, and connecting pipes to bring the water to the radiators and back to the boiler. Connected with the pipes at the top of the home is an expansion tank which takes care of the increased volume when the heated water expands. Water leaves the boiler at a temperature of 175° to 185° F. and returns to it ten degrees cooler, heat being transferred from boilers to radiators by convection. The cooled water is heavier than hot water, and flows down through the pipes.

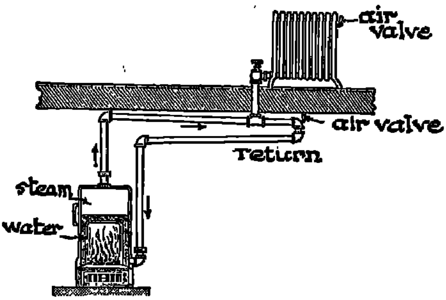


Can you explain how the hot-water heating system works? Under what conditions might the expansion tank overflow?

As soon as the hot water reaches the radiator, heat is conducted through the metal to the outside surfaces. Air coming in contact with the radiators is heated, and then gives off this heat to the other objects in the room by convection, while some heat is radiated directly to the walls and objects in the room.

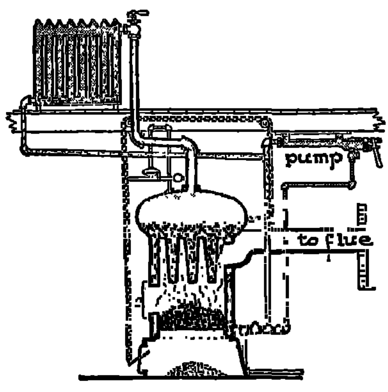
Steam Heat in the Home. In the steam-heating systems, the parts are much the same as in the hot-water system, except that there is no expansion tank. Steam, made

by boiling water, passes through the pipes to the radiators. The heat required to change water to steam is stored up in the steam, and when steam condenses it gives up this stored heat. The water formed by this condensation leaves the radiator and is brought back to the boiler again, either by a system of return pipes or, if the house is small, it may go back through the steam pipe.



How are the radiators of a steam-heating plant warmed?

Vapor Heating. In the vapor-vacuum system of heating a large part of the air is withdrawn from the boiler, pipes, and radiators by means of an air valve or pump in the basement. If one half of the pressure is removed, the water will boil at 180° F. When this vapor steam condenses in the radiator, it gives up more heat than the same weight of ordinary steam does.

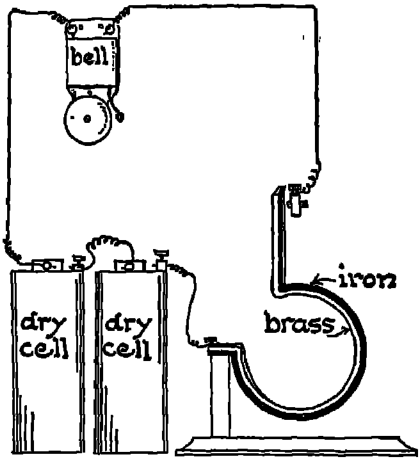


Can you explain how the vapor-vacuum system works? What is the use of the chain attached to the furnace door?

The Thermostat in the Home. Heating in our homes is often controlled by a thermostat, which automatically regulates the drafts, opens and closes the valves of the radiators, operates the oil heater, keeps the electric iron from overheating, operates the motor of the refrigerating

machine, controls the temperature of the gas oven, and keeps the water hot in the hot-water supply system.

There are several types of thermostats. Let us try to understand one of them. One of the most commonly used thermostats is made of iron and copper or brass bars welded or riveted together with one end of the compound held securely. When heat is applied, the copper bar will expand in length more than the iron. This makes the compound bar bend with the copper on the outside curve. The free end of the bar is moved by this action and may easily be the means of closing an electric circuit. The thermostat automatically keeps the temperature of the room within about one degree of the temperature for which it is set.



Explain with reference to the text how the thermostat works.

Fuels Used. While wood is still used in many country homes, coal, oil, and gas are the most used fuels, and electricity is coming into use for heat where it is cheap. Anthracite coal is preferred to soft coal for the furnace because it makes less dirt. On the other hand, it is much more expensive. A new automatic stoker has recently been invented which uses small sizes of coal. This mechanism is so complete that it not only feeds coal to the furnace, the heat of the fire being under thermostat control, but it also carries the ashes from the furnace by means of an automatic conveyer. Such a device will undoubtedly

cause a greater use of coal of small sizes, now only usable in factories.

ADVANTAGES AND DISADVANTAGES OF HEATING SYSTEMS

Kind of Heating	Advantages	Disadvantages
Fireplace	Aids ventilation. Low cost. Takes little space.	Low efficiency. (20 per cent.) Uneven heating.
Stove	Low cost. Efficient heating. (70 to 80 per cent.)	Takes space in room. Requires much care. Makes dirt and dust. A great fire hazard.
Warm-air furnace	Low cost to install. Aids ventilation. Easy to operate. Changes temperature quickly. No radiators in room.	Large consumption of fuel. Brings dust into rooms. Danger from coal gas. Irregular heating. Some rooms hard to heat.
Hot water	Small consumption of coal. No dust. Easy to operate. Even temperature.	High cost of installation. No ventilation provided. Danger from freezing. Changes temperature slowly. Radiator space large. Unsuited to tall buildings.
Steam	Small consumption of coal. No dust. Distant rooms easily heated.	High cost of installation. No ventilation. Changes temperature slowly. Radiators take up space. Sometimes noisy.
Vapor	Small consumption of fuel. No dust. Changes temperature fairly quickly. All rooms easily heated.	High cost of installation. No ventilation. Radiators take up space.

Oil Burners. There are many types of oil burners, but in the majority of them a certain quantity of air is blown through pipes and the oil is pumped through a spraying nozzle so that a mixture of oil vapor and air is delivered to the burner, which is placed in the fire box of the heater. A smokeless flame results.

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

sinks	air	heat	register
stove	gas	temperature	fire
tank	expands	rises	steam
closed	open	cold	radiator
storage	close	hot	water
vapor	expansion	boiler	

Warm-air heating depends upon the fact that (1)____ warmed in a furnace (2)____ by convection. Circulation of hot water from a (3)____ where the water receives heat, to the (4)____ where it gives up heat and back again, is utilized in (5)____ (6)____ heating. (7)____ under pressure can be sent to radiators at great distances from the boiler and so is desirable for heating large or tall buildings. Automatic control of the (8)____ and room (9)____ is easily secured through the use of oil burners for heating by means of a thermostat. To make the fire burn most strongly I would (10)____ all check drafts, (11)____ the draft under the grate, and (12)____ the damper in the smoke pipe. To take up the increase in volume of water when a hot-water heater is first started, an (13)____ (14)____ is necessary.

ESSAY TEST

Raymond Tells of Heating Plans for the New House

Read carefully and critically. List all the errors and suggest corrections.

When father decided to build a new house he asked mother what kind of heat she wanted in it. The family was all present and as I recall this was the conversation.

Betty. I want the vapor-vacuum heat. Everybody is having it now. It's the cheapest and best.

Alice. I think regular steam is better. I don't want any vacuum radiators in my room. They may explode any time.

John. Anything suits me if you have an oil burner. I'm tired of shoveling coal and sifting ashes.

Raymond. For steady uniform heat there is nothing better than the warm-air furnace.

Father. Just a minute. I asked mother what *she* wanted and you won't give her a chance to tell.

Alice. She doesn't care anyway.

MOTHER. Yes, I do care. I do not want a dirty hot-air furnace or the oil heater. They fill the house with dirt. Coal is always dusty. I don't want any unsightly radiators in my rooms because they are always in the way and there is no way to get rid of them if you use steam or hot water.

BETTY. Well, Mother, all there is left is the fireplace or a wood stove in each room.

RAYMOND. Oh, we may as well go back and start our fire with a whirling stick.

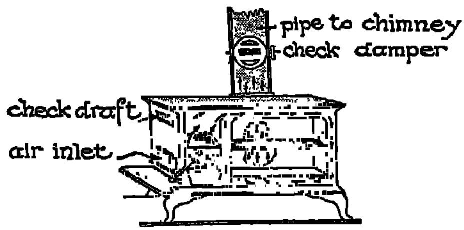
MOTHER. It's not quite so bad as that. Do you not know that electricity gives the cleanest and most easily controlled heat of any kind of heating? That's the kind of heat I want in the new house.

CHILDREN (*in chorus*). That is great; we want it too.

FATHER. I see I have made a mistake in getting your advice. With electricity costing 12¢ a kilowatt-hour, it's a question of having the house without electric heat or of having electric heat and no house. I cannot afford both. So think it over and some other time we may discuss it again.

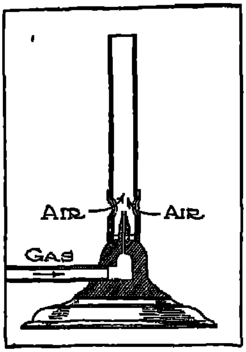
PROBLEM II. HOW IS HEAT USED IN COOKING?

The Coal Range. The ordinary kitchen range for burning coal has a small fire box lined with fire clay, an ash pit, and an oven. The main air supply enters through the draft opening in the door to the ash pit under the coal, and passes through the layers of coal, where it aids combustion. The hot gases, coming from the burning coal, pass directly to the chimney through the stovepipe, or around the oven and then to the chimney. There is a check draft which admits air directly to the fire box above the coal. A damper, and frequently a check draft, which may be used to check the fire, is placed in the stovepipe. An



Explain the air currents shown in the diagram. Is the oven damper (not shown) up or down?

oven damper, if raised, causes the hot gases to pass around the oven before entering the stovepipe. When the oven damper is down, the hot gases pass directly to the stovepipe.

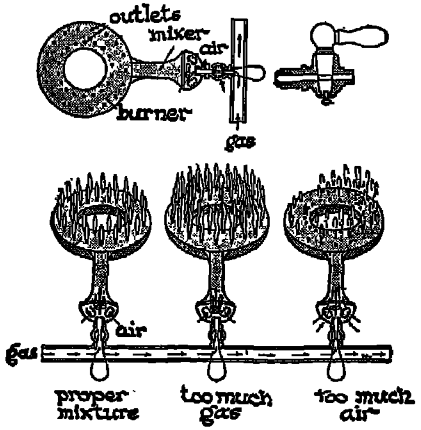


Can you explain the principle of the Bunsen burner?

Demonstration 2. The Bunsen Flame.

Close the air holes in a Bunsen burner. Turn the gas on full and light it. Notice the yellow color of the flame. Pass a saucer or a piece of heavy white paper through the flame and note what happens. What is the black substance? Where did it come from? Now open the air holes in the burner. What happens to the color of the flame? Why do you suppose the color changes? With the air holes open, turn the gas down until low and then little by little reduce it until suddenly the flame "strikes back" to the base of the burner. If the gas is now turned on full, it makes a roaring sound. Can you tell why? After it strikes back turn the gas off.

The Gas Range. All the burners of the gas range are of the Bunsen type. Gas is brought to a mixing chamber through a small hole, and air comes in through larger openings. Gas mixed with air leaves the small holes of the burner, where it is burned.

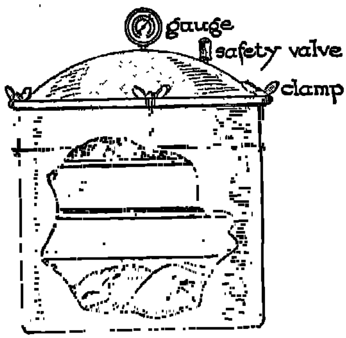


Why should the burner on your gas range be properly regulated? Can you regulate it without calling a gas man?

It is very essential to keep the burners clean; also to have the proper adjustment between the amounts of gas and air. Too much air causes the flame to strike back or go out.

Too little air makes a sooty flame. Never allow the gas burner to burn after it strikes back, for it throws off a poisonous gas into the atmosphere. To prevent the escape into the room of water vapor and carbon dioxide from the gas burning in the oven, a stovepipe may be connected with the chimney.

Oil Ranges. Many people who have no gas in their houses and many who formerly used coal have equipped the coal range with an oil range burner and burn fuel oil. A small reservoir, which is an inverted bottle having its mouth sealed in oil at a constant level, maintains an even flow of oil into the burners in the stove. When the oil is used up so that the level comes below the mouth of the bottle, a few bubbles of air rise in the bottle and allow an equal volume of oil to come out. Do you recall the science principle on which this works? In the fire box of the stove, the oil is heated and changes to a gas which is mixed with air and the result is very much like that of burning natural or manufactured gas. The hot gases from the combustion of the oil heat the top of the stove and may circulate around the oven just as they would if coal were burned.

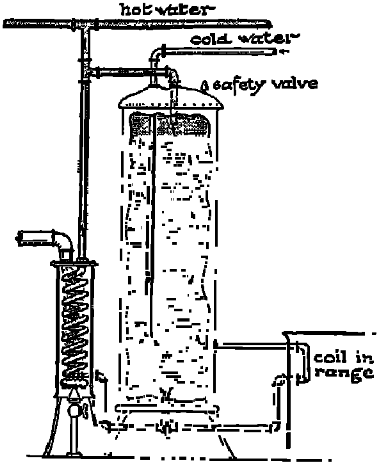


Under what conditions of living might a pressure cooker be a necessity?

Pressure Cookers and Waterless Cookers. When a vessel containing boiling water is closed in order to prevent the escape of steam, the pressure increases and a rise in temperature follows. Twenty-five to fifty per cent of the fuel can be saved by using pressure cookers. Waterless cookers are really a type of pressure cooker which depend upon the water in the foods to supply the steam.

The pressure is not greatly increased in the waterless cooker and so there is not much saving in time and fuel, but without added water there is less loss of vegetable juices.

The Hot-Water Supply. The hot-water supply for household purposes is usually obtained from the hot-water storage tank connected to the coal range or to an independent heater. In the range, the water is heated in a pipe close to the fire box, and leading to the boiler. Sometimes a gas stack is also attached to the tank. The gas flame heats a coil containing cold water, and the rapidly heated water rises as it becomes lighter and passes into the pipe of the hot-water tank. When the hot water is drawn from the faucet, a supply of cold water rushes in through the pipe which enters at the top of the tank and extends down to a level just above the top of the heating device. In the instantaneous gas heater, the gas is automatically turned on and lighted by a pilot flame when the faucet is opened. The water is heated as it passes through the coiled pipes in the flame.



What are two possible methods of heating the water in this boiler? Where is the hottest water in the boiler? Why?

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

check	wasted	juices	gas
smoke	saved	draft	fuel

oxygen	pipe	air	door
pressure	time	soot	insulated
carbon	oil	pit	damper

In the coal range air to make the coal burn enters through the (1)___ opening in the (2)____ to the ash (3)____. A useful control of burning is the (4)____ in the stove pipe. Much gas is (5)___ in cooking by turning the gas on full when turning it on partially will be sufficient, and by improper adjustment of the (6)____. (7)____ is deposited on vessels in the gas flame if there is too much (8)____ or too little (9)____. The (10)____ cooker saves time and (11)____. The waterless cooker saves the valuable (12)___ of the vegetables. Much gas can be saved if the walls of the gas oven are (13)____.

ESSAY TEST

Janet Is in Charge of the Kitchen

Read carefully and critically. List all the errors and suggest corrections.

Janet (*at the telephone*). Hello. Is this the gas office? Can you send a man up here at once? The trouble? Trouble enough; the stove I bought from you three months ago is all worn out or the gas you make is poor. It takes me half an hour to heat a pint of water. (*Hangs up the phone. Janet sits down to finish the story she has been reading most of the morning. The doorbell rings.*)

Janet. So you're the gasman. It's a wonder anyone will work for them. You should see the awful bills they send me, and such poor gas. They must be making a mint of money. Yes, this is the stove right here. See that good-for-nothing flame?

Gasman. Well, that is hardly worth calling a flame, is it? Did you ever have things boil over? Do you clean the burners weekly?

Janet. One can't watch the stove all the time. Of course things boil over. But that doesn't make the gas poor, does it? No, I don't clean the burners. I never heard of such a thing. I wash my dishes once a day and I guess that's enough washing for me.

Gasman. See here, lady. Do you see all that dirt, dust, and lint there where the air goes in? That shuts off the air supply and would make a smoky flame if the burner tubes were large enough to let much gas out. They are so clogged with grease from spilled food that it doesn't matter much now. Look, if I push this wire through these tiny holes to clean off the dirt, the flame

comes up four times as tall as it did. The burner needs boiling out in lye and cleaning each hole with the wire. Then keep the air inlet free from dust and you will have no more trouble. Good day, ma'am.

JANET. Well, well, what a nuisance, but I suppose I'll just have to get busy and clean all those burners, but I do begrudge the time when I might be reading.

PROBLEM III. WHAT ARE THE COMMON FIRE HAZARDS?

Fire Waste. Valuable as fire is when controlled, once out of control it is one of our greatest enemies. The fire loss in the United States amounted to about $316,897,733 for the year 1933. About 85 per cent of these fires are classed as preventable. Each one of us must take some responsibility in trying to reduce this unnecessary fire waste. It is in our homes that we can do most.

Matches. In the United States probably half a million flames are produced with matches every minute. Our chief concern about matches in the house is to keep them away from children who are too young to realize the danger of fire, and from rats and mice, that cause fires by gnawing the match heads. Still another way is to use safety matches, for the ordinary match may ignite if it is dropped or stepped on. The fire losses in the United States which are known to be due to fires started by matches and smoking are about $30,000,000 a year, the largest known cause of fire.

Always put out your camp fire. Why?

Camp Fires and Bonfires. Scarcely a week goes by but that we read of some child being burned to death as a

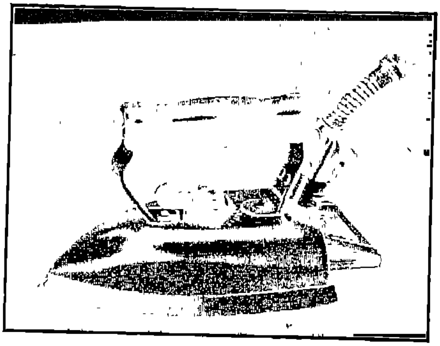
result of playing with fire. One of the most frequent causes of accident both to children and their homes is from bonfires. Never build a fire where it can spread and never build a fire when the wind is blowing. Be especially careful in dry weather. Sparks often set fires at a distance. Camp fires should always be carefully put out with water before leaving them, as many forest fires have been started from smoldering embers left by campers.

Flames for Light. The candle, kerosene lamp, and gas flame are common sources of danger in the home. Many fires have been started from curtains blowing into a flame and catching fire. It is unsafe to leave a burning lamp or gas flame unwatched for a long time. Candle shades made of paper or cloth should be protected by a mica chimney which separates them from the flame. Use lamps and candlesticks which stand solidly on a broad base. Filling an oil lamp which is burning may cause the flame to jump back and set the kerosene on fire.

Fire Dangers from Heating Devices. Perhaps most deaths from burning are the result of carelessness in kindling a fire in a stove. Scarcely a week goes by that you do not read in the papers an account of someone who used kerosene to kindle the fire and was seriously, if not fatally, burned by an explosion when a mixture of the oil vapor and air was ignited. Hot stovepipes, heaters, or hot-air ducts placed too close to woodwork may cause a slow smoldering fire which will spring into a blaze when fanned by a draft of fresh air. Ashes are never safe when left loose on the cellar floor or in wooden receptacles. Metal containers are the only safe ones.

The Automatic Electric Iron. Many unnecessary fires have been started from electric devices such as irons. The automatic electric iron has a device which controls the degree of heat. When the temperature gets a few

degrees higher than is needed for ironing, the current is automatically switched off. When the iron cools a few degrees, the current is automatically switched on. This control is brought about by means of a thermostat contained within the iron. Electric heating devices use a large electric current which is capable of starting a fire in the wires that are poorly insulated or installed. Do not use fuses of higher capacity than the installed wires are able to carry safely.



How can an electric iron be made safe automatically?

Miscellaneous Fire Dangers in the House. The nitrogen-filled incandescent lamp gives us a more efficient light than we have ever had before in the house. It has, however, brought a hazard with it. It heats to a high temperature and may ignite cloth or paper.

Celluloid articles, inflammable tissue used in decorations, and, of course, gasoline and alcohol are always hazards. Gasoline and other inflammable liquids should be kept in metal safety cans. Another great danger from gasoline is that the vapor mixed with a certain quantity of air will burst into flames and explode if it comes in contact with a bare flame, a spark, or a glowing coil of a radiant electric heater. For this reason smoking should never be done near a gasoline filling pump, nor near the tank of a car, and the greatest care should be taken to extinguish all cigarette or cigar "butts." Another fire hazard in the house has come with the new

Publishers' Photo Service

The results of a recent fire at Stamford, Conn. How do you account for such widespread destruction?

method of spraying paints and lacquers for refinishing. These paints often contain liquids which are inflammable. Waste paper and rags are also fire hazards.

Spontaneous Combustion. Sometimes rags or cotton waste are saturated with certain oils, such as linseed oil used in paints, and as they dry, the oils combine with oxygen, forming heat. Since rags and cotton waste do not give off their heat easily, the heat may increase sufficiently to reach the kindling point of the materials, which will burst into flames and burn rapidly. This is known as *spontaneous combustion.* The loss of many farm buildings is laid to spontaneous combustion of hay. If the hay is not thoroughly cured or if wet with rain or dew when put into the mows or stacks, oxidation takes place, and enough heat may accumulate to raise the hay to its kindling temperature and cause it to burn.

Heating Dangers. The various devices connected with the heating of a house offer a multitude of fire hazards. Old chimneys may crack, the bricks loosen, and sometimes a brick drops out, leaving an opening close to inflammable materials. In 1929 defective flues cost nearly $20,000,000 in fires. Smoke pipes may loosen and drop sparks. Wood or paper laid upon a heater is another source of danger. Hidden live coals may set fire to a wooden container. The best preventive of fires from these sources is frequent inspection and efficient correction of the defects found.

SELF-TESTING EXERCISE

Select from the following list those words which best fill in the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

phosphorus	fire	explosion	hazard
kerosene	flame	glass	safety
compound	explosive	combustion	spontaneous
matches	match	oil	box

The safest match to use at home is called the (1)____ (2)____. It can be lighted only by scratching it upon the (3)____. Many accidents and serious fires are caused by using (4)____ to kindle fires. Damp hay often takes fire in process called (5)____ (6)____. Ashes kept in wooden boxes make a (7)____ (8)____. Gasoline vapor mixed with air is a dangerous (9)____.

ESSAY TEST

Julian Is Fire-Hazard Inspector for a Day

Read carefully and critically. List all the errors and suggest corrections.

I was appointed by the Fire Captain to inspect the cellars in my neighborhood. He gave me a badge which allowed me entrance to all houses. Here are some of the things I found which are all serious fire hazards.

1. A wooden trash barrel touching the warm-air furnace.
2. A stovepipe 3 feet from any woodwork unprotected by asbestos.
3. An empty fire extinguisher.
4. A lot of rags in a bag hanging to a brick support.
5. A number of burnt matches on the cement floor.
6. A 275-gallon steel oil tank in the cellar.
7. An electric cord with the insulation badly worn.
8. A bottle of gasoline on a shelf in the stairway.
9. A bundle of newspapers drying on top of the furnace.
10. A leaking gas pipe.

I turned this report in to the fire captain but he told me half of the items in my list were not dangerous. Which five did he accept as fire hazards?

PROBLEM IV. HOW MAY FIRES BE PUT OUT?

Extinguishing Fires. A fire to continue to burn must have fuel, oxygen, and a temperature above its kindling temperature. Deprive a fire of any one of these essentials and it will go out. Three principles underlying the methods used to extinguish fires are removal of fuel, smothering to keep oxygen away, and cooling.

Digging trenches and covering combustible material with sand in brush and grass fires, back firing in forests, and dynamiting buildings in large city conflagrations are methods used to extinguish fires by removal of fuel.

Methods of smothering depend upon the fire. A kettle of burning fat may have a metal cover placed over it and a wet cloth placed tightly over that. If a person's clothing is on fire, he may be rolled up in a blanket or large rug. Steam or carbon dioxide, if available, may be discharged upon a small fire and remove the oxygen effectively.

Water is the most universal fire extinguisher. It has many properties which favor its use. It can be thrown long distances in a steady stream. It is non-combustible. One pound of it has greater cooling effect than the same

Which of these two methods is the more efficient? Why?

weight of any other common substance. On changing to steam it increases 1700 times in volume. The change from liquid to steam absorbs a large amount of heat, thus adding to its value as a cooling agent. The steam also tends to smother the fire by excluding air.

Demonstration 3. How to Extinguish Burning Liquids.

Materials. Lard, gasoline, evaporating dish, ring stand, heavy cloth, carbon tetrachloride, and test tubes.

Method and Observations. *A*. Heat a teaspoonful of lard in an evaporating dish. Set the lard on fire. Pour two or three drops of water from the test tube into it. Cover the dish with a wet cloth. What happened when water was dropped into hot fat? What happened when the flame was covered with the wet cloth?

B. Pour a tablespoonful of gasoline into each of two evaporating dishes in a shallow enamel pan. Set them on fire. Pour water into one and carbon tetrachloride into the other. Does water extinguish burning gasoline readily? Does carbon tetrachloride?

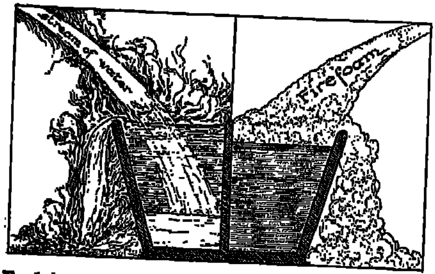
Conclusions. What is your conclusion regarding one effective method of extinguishing burning fats? burning gasoline?

The Hand Chemical Extinguishers. The carbon tetrachloride, the foamite, and the carbon dioxide fire extinguishers are types of chemical extinguishers suitable for use in the house, the school, and the shop when the fire is small.

The carbon tetrachloride extinguisher is a small container to which a force pump is attached. When the container is opened, and the pump works, a stream of liquid is thrown out which changes to a gas when it strikes the flame and smothers the flame. Whenever this extinguisher is used, take care not to breathe the fumes given off by it, for they are very harmful. This type of fire extinguisher is particularly valuable for putting out small gasoline and oil fires where water would spread the fire.

In the foamite extinguisher two solutions are kept separate until used. Solution 1 contains sodium bicarbonate and an extract of licorice root. Solution 2

contains aluminum sulphate. When the extinguisher is inverted, the two solutions mix and set free the carbon dioxide, which makes sufficient pressure to force the liquid out. The carbon dioxide escapes in the form of fine bubbles with a tough film produced by the licorice extract. The carbon dioxide is held in these bubbles over the burning surface and excludes the air. This is one of the most effective means yet devised for fighting oil fires.



Explain why the principle used in the right-hand diagram is so effective.

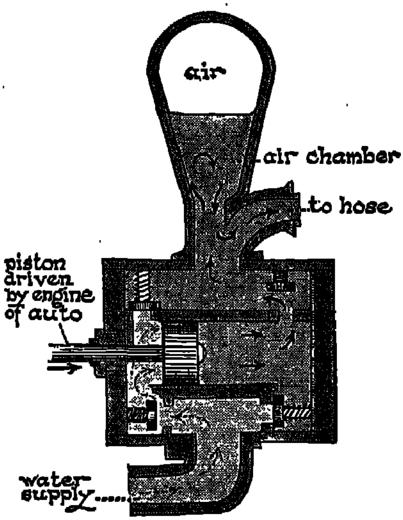
The small carbon dioxide extinguisher holds two and a half gallons of water, in which are dissolved one and a half pounds of baking soda (sodium bicarbonate), and an 8-ounce bottle containing 4 ounces of strong sulphuric acid is suspended above the solution. When the extinguisher is inverted, the acid mixes with the soda solution and produces carbon dioxide gas. This gas creates such great pressure that the liquid is frequently forced out through the hose to a distance of 40 to 50 feet.

How would you make this extinguisher work?

Fire Protection in Public Buildings. Every year, thousands of people lose their lives in fires; and many public buildings, including schools, are destroyed. Every school, orphanage, hospital, and other public building ought to be equipped with a private fire-alarm system, and in schools this system should be arranged so that it can be detached from the city alarm when fire drills are held. Most fires that occur

in schools originate in closets or in the basement; therefore, these parts of the building should be equipped with an automatic sprinkler system.

City Fire Engines. In most fire departments we find two kinds of engines, the *chemical* and the *motor pump.* The chemical is usually the first to arrive at the fire and is able to extinguish a small fire. It is really a large carbon dioxide fire extinguisher in which a solution of sodium bicarbonate and concentrated sulphuric acid is used. In the motor pump, the gas engine which drives the auto truck is made to drive a powerful double-acting force pump. This force pump draws water from any source — hydrant, wells, or rivers — and will throw a stream of water more than one hundred feet. The action of the pump can be seen by studying the figure above, which shows how the piston rod of the engine is joined to the piston of the pump.



Why is this called a double-acting pump? Explain how it works.

Demonstration 4. To See How the Force Pump Works.

Materials. Glass model force pump with air chamber, shallow jar, or basin.

Method and Results. Operate the pump. Watch the valves. Explain the action. What seems to be the purpose of the air chamber?

Fire Boats. The waterfront of New York measures about 578 miles, or a distance equal to that from New York

Wide World

A bad fire on the New York waterfront. What are the advantages of fire boats here?

to Cleveland. Many fires occur along the wharves and upon boats tied to the piers. It is essential, then, that large port cities, like New York, Baltimore, or San Francisco, have fire equipment to use not only on the land but also on the water. An opening for fighting many of these fires is better secured from the water side. For this purpose the fire boats have been developed. The boats have such powerful equipment that at a recent fire on a bridge, a fire boat on the water below threw a stream of water 136 feet high and extinguished the blaze.

SELF-TESTING EXERCISE

Select from the following list those words which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

nitrogen	carbon	washing	can
soda	hydrogen	ammonia	temperature

salt	kindling	safety	sprinkler
chemical	fuel	smothering	candle
electric	water	baking	open
oxygen	tetrachloride	licorice	bottle

Every fire requires the gas (1)____ which is present in the air. The process of extinguishing a fire by excluding air from it is called (2)____. A fire will go out if the temperature of the burning substance falls below its (3)____ (4)____. The three essentials for a fire are (5)____, (6)____, and keeping the (7)____ above the kindling point. An extinguisher well suited for putting out gasoline fires is that which uses (8)____ (9)____. The carbon dioxide which produces pressure in one type of extinguisher is produced by the interaction of sulphuric acid and (10)____ (11)____. The safest illumination for the Christmas tree is the (12)____ light. Gasoline if kept in the house should be kept in a (13)____ (14)____.

ESSAY TEST

Alice Reports on Her Trip to the Fire Station

Read carefully and critically. List all the errors and suggest corrections.

The fire chief gave me a lot of information and also asked many questions. First he asked, "What is the best all-round fire extinguisher?" I said, "Water." "Right," he said, "but there are times when it is unsafe to use it." I asked, "When?" He replied, "Water must never be used when burning oil is where it can set fire by spattering. A stream of water must never be used where it will touch bare electric wires carrying high voltage."

He then showed me how they loaded a carbon dioxide extinguisher. He filled a small bottle full of dilute sulphuric acid. He filled the extinguisher full to the top with a solution of common salt. He set the acid bottle in a little cage in the cover which was screwed tightly on. He poured some carbon tetrachloride out on water to show it will float on water. Because it floats it extinguishes flame by smothering it. He made a diagram to explain the pump on their engines. This was difficult but it seems the pump pulls water out of a hydrant and atmospheric pressure causes it to go out the delivery pipe with great force.

THE REVIEW SUMMARY

In preparing a summary of what you have found out in this unit, you will want to place emphasis on the big ideas which have come from the applications of the facts you have learned and the demonstrations you have seen. Doubtless you have done some additional reading which has helped you put together some of the facts into generalizations or fundamental underlying principles. For this unit some of these generalizations are:

1. Heat can be transported by storage in air, water, and steam to places remote from its origin.
2. Unequal expansion of different materials makes possible the automatic control of temperature.
3. The proper burning of a fuel is controlled by regulating the air supply.
4. Enormous fire losses result from the careless acts of man.
5. Fire-extinguishing devices generally aim to cut off the air supply or to cool the burning material.

Before making your review summary for your workbook, test your knowledge of the facts of the unit by checking over the text so as to be sure you know the facts underlying the science principles or generalizations. Then, using this material and everything you have read, seen, or done yourself, make your summary outline. This outline you may use when you make a recitation.

TEST ON FUNDAMENTAL CONCEPTS

In a vertical column under the heading CORRECT *write numbers of all statements you believe are true. In another column under* INCORRECT *write numbers of the false statements. Your grade = right answers* × 2.

I. **Fire requires:** (1) carbon dioxide, (2) oxygen, (3) an incombustible material, (4) inflammable material, (5) heat.

II. **When a fire is burning in the fireplace, the room is warmed chiefly by means of:** (6) conduction, (7) convection, (8) radiation, (9) circulation of air, (10) oxidation.

III. **When coal is burned in a stove to warm a room:** (11) less than $\frac{1}{4}$ of the heat from the fuel warms the room, (12) about 75 per cent of the heat passes out the chimney, (13) about $\frac{3}{4}$ of the heat is given to the room, (14) all the heat the room gets is by radiation, (15) conduction largely helps in warming the room.

IV. **The devices used to assist in regulating a fire in a furnace are:** (16) a grate, (17) a steam gauge, (18) a check draft, (19) a safety valve, (20) a damper.

V. **A steam-heating system requires the use of:** (21) a thermostat, (22) an expansion tank, (23) larger radiators than for hot water, (24) a safety valve, (25) a water gauge.

VI. **Heat may be efficiently carried from a central heater to all parts of a large house:** (26) when it is stored in steam, (27) by radiation, (28) by convection air currents, (29) by conduction, (30) when it is stored in water.

VII. **To get a hot fire as quickly as possible:** (31) add a lot more coal; (32) open draft in ash pit; (33) open check in stovepipe; (34) open damper in stovepipe; (35) close check draft of fuel door.

VIII. **The flame from a Bunsen burner is:** (36) clean and nearly colorless when the air inlet is properly adjusted; (37) smoky when much air is admitted; (38) likely to strike back when air is almost all cut off; (39) hottest when incandescent (giving out light); (40) produced by chemical action.

IX. **To prevent fire hazards in the home:** (41) allow no cracks in chimneys; (42) allow no worn insulation on electric wires; (43) see that steam pipes insulated with asbestos do not touch the plastered wall; (44) see that hot-water pipes do not touch any woodwork; (45) have inflammable rubbish quickly removed.

X. **The principles underlying fire extinguishing are:** (46) removal of combustible material; (47) stopping of convection currents; (48) shutting off the supply of oxygen; (49) cooling below kindling temperature; (50) living near a hydrant.

PRACTICAL PROBLEMS

1. There are four draft controls on a furnace.

(1) Draft in ash-pit door
(2) Check draft in fuel door
(3) Damper in smoke pipe
(4) Check draft in smoke pipe

Copy the form given below and record in the blank spaces what you would do to the controls in each case, using the terms: *open, closed, partly closed.*

	1	2	3	4
1. To start a fire				
2. To keep a moderate fire . . .				
3. To cool an overheated furnace .				
4. To keep the fire over night . .				

2. How can you remove grease spots without danger of fire?

3. How would you clean out a coal range to make the oven bake better?

4. Find out the names of three commercial fire extinguishers and learn the principles upon which each puts out a fire.

5. Suppose you discovered a bad fire in the cellar. Tell in detail just what you would do.

INTERESTING THINGS TO DO, READ ABOUT, OR SEE

1. The coal range, how it is constructed and operated.
2. Paper-bag cooking.
3. Removal of fire hazards from my home.
4. Borrow from the gas company different types of burners and give a "lecture" to the class upon them.
5. Fireproof construction.
6. A visit to the fire station.
7. Report on a popular science book I have read.

SCIENCE FOR LEISURE TIME

1. Collect from the newspaper clippings about fires for a period of 4 weeks.

2. Collect pamphlets on heating devices. Prepare a booklet and show all the different types of heating devices.

3. A fire extinguisher. Prepare an apparatus like that shown in the drawing. Put a solution of baking soda in the large bottle, and sulphuric acid or vinegar in the test tube. Fasten the stopper in tightly. Even then it may leak, so wrap a cloth around the mouth of the bottle and stopper and hold it in place. Invert the bottle, and direct the nozzle into the sink on some burning material.

4. Make a collection of heat-insulating materials for your personal science museum.

5. Make a fire-hazard score card form for the home and see how your home scores.

SCIENCE CLUB ACTIVITIES

1. A Carbon Dioxide Race

Boys and girls who enter this contest must construct a trough through which the carbon dioxide is to run. This may be of wood

or tin. Set the trough at an angle of 45° from the horizontal. Christmas candles cut to 1 inch in height are placed upright in the trough at intervals of 6 inches. Each pupil is provided with a large battery jar and cardboard cover. One heaping tablespoonful of baking soda is placed in each jar. To this is added 35 cc. of dilute hydrochloric acid. The cover must be kept on the jar to prevent the loss of carbon dioxide. The candles are all lighted. At the signal — one, two, three, *go* — each pupil opens the jar and pours the gas into the trough at the top. The one that extinguishes the largest number of candles wins. In case of a tie, play it off by starting with smaller jars of carbon dioxide.

2. Invite a fireman from your locality to attend one of your meetings and to tell some of his experiences.

3. Elect a committee to take charge of the science bulletin board for a week. The committee may decide what topic relating to heat it will emphasize.

4. Consult a dealer in oil burners. Get diagrams. Explain to the club members just how the oil burner operates.

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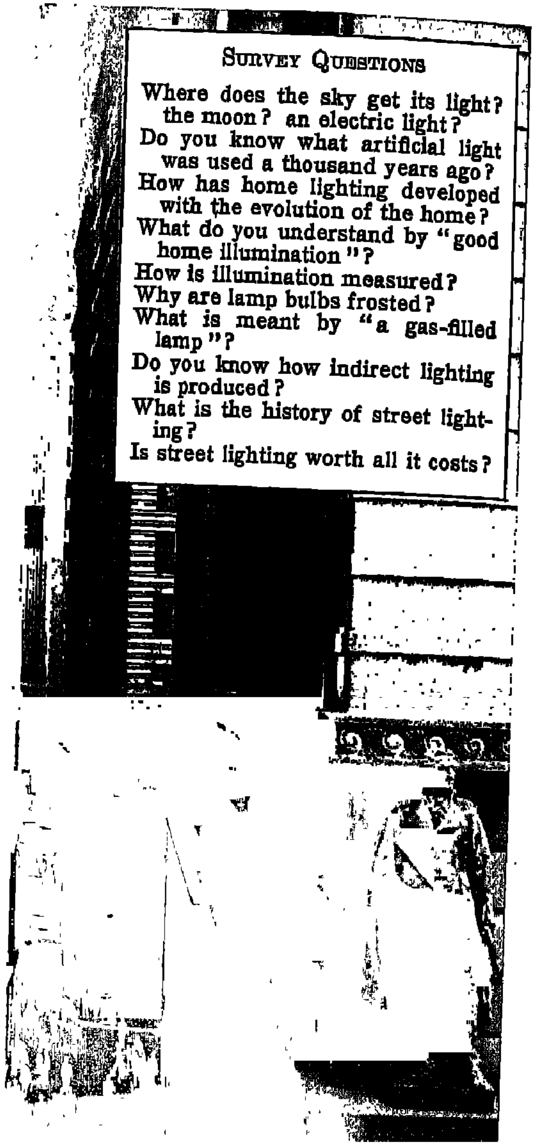


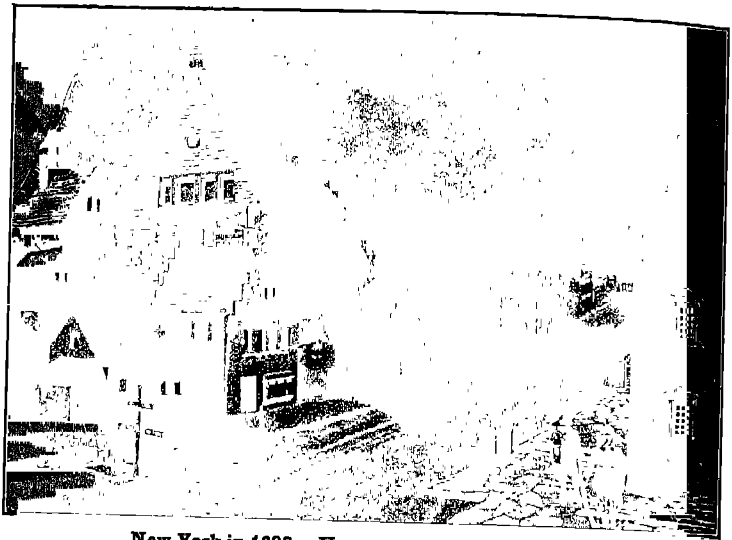
Philip O. Gendreau

UNIT VI

LIGHT IN HOME AND COMMUNITY

PREVIEW

Artificial light has been used since the beginning of civilization. Over 6000 years ago pitch and resin were often burned in vessels, and in Greek and Roman times the use of oils in open lamps was usual. The use of wicks in oil is as old as the pyramids of Egypt. When oil first came into use, it burned with a smoky flame, but in 1783, Argand, a Swiss physician, made a lamp with a cylindrical wick having a central draft. This burner made a clean smokeless flame. Petroleum was first introduced for lighting purposes in 1859 and grew so rapidly in use that, in 1860, 2,000,000 barrels were used. Today in spite of advances in science petroleum is still used in many places where gas or electricity is not available. A few years ago gas lamps were commonly used with a mantle which would glow when heated, thus producing a white light. Such Welsbach lamps are used in our camps today where we use gasoline under pressure. But the light that has come into common use today is electricity. The story of the invention of this light by Thomas Edison is well known. He worked many years, spent hundreds of thousands of dollars, and made thousands of experiments before his first successful lamp was finally produced in 1879. In this he used a carbon filament made from thread. Later he made a filament of bamboo, but now metal filaments are used, tungsten being the best metal for this purpose.



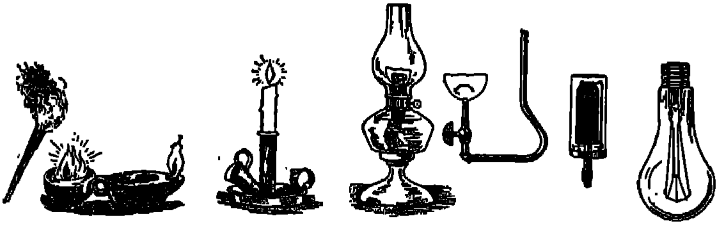
New York in 1698. How were the streets lighted?

The story of street lighting is interesting. In 1415 the lord mayor of London ordered all prosperous citizens to hang lanterns in front of their homes to serve as street lights. For three hundred years householders were obliged to hang lanterns in front of their houses during the winter evenings. Forgetful people were reminded by the passing watch with these words:

"Light here, maids, hang out your light,
And see your horns be clear and bright,
So that your candle clear may shine
Continually from six to nine,
That honest men may walk along,
May see and pass safe without wrong."

In 1698, a law was passed in New York to the effect that each seventh house should hang out a light on a pole. Previous to that time the only street lights were those that came from the windows of houses. In 1774, the city of Boston purchased about four hundred lamps from

England. In the latter part of the eighteenth century London was well lighted with oil lamps having wicks and glass chimneys. Street lighting by gas was introduced in England in 1807, and in Baltimore, Maryland, in 1817.



Copy this diagram for your workbook and place dates against each method of lighting to show the period of greatest use.

Today oil has been given up for street lighting. In a few places where natural gas is abundant it is burned in mantle burners. This is the age of electricity and most of our cities today are lighted by that means. Electricity was first used for street lighting in 1879 when twelve arc lights were installed in a public square in Cleveland.

Before you turn to the study of your unit think back to the science principles you learned last year about light. There are several important facts that you then learned about light as follows:

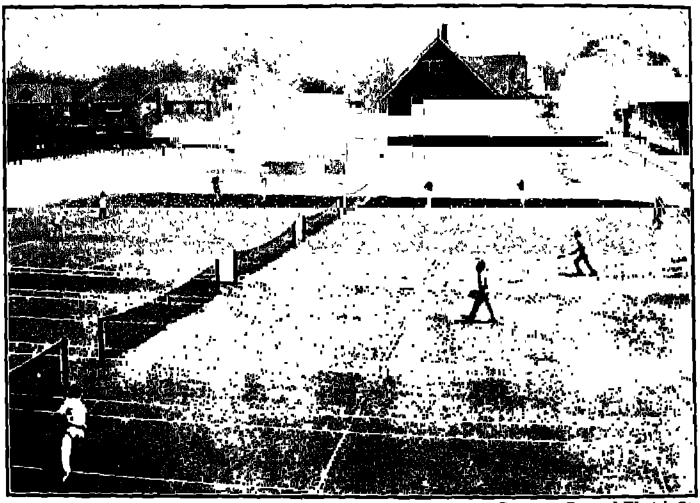
Science Principles

1. Light travels in straight lines with tremendous speed.
2. Light rays may be bent by reflection and refraction.
3. Light produces important chemical changes.

With these facts as a foundation we can build on them with the material you will now take up in the three problems of this unit.

PROBLEM I. WHAT DETERMINES NATURAL LIGHT IN THE HOME?

Light from the Sky, a Factor in Lighting. We have already learned that sunlight is diffused by dust particles in the air. The light from the sky is only about $\frac{1}{2,000,000}$ of that of the sun, but it is of the greatest importance to us. In country homes not all rooms are directly lighted by the sun, and in the city apartments very few rooms have any direct light. Diffused light is all that comes to us there. Sunlight is of utmost importance to us not only because it illuminates objects, but because it benefits health, for direct sunlight destroys harmful bacteria. We also have learned recently that sunlight contains the ultra-violet rays so necessary to health. We must remember, if we live in the country, that too much shade and too many trees are as bad as too few, and that we ought to get some direct sunlight at some time of the day in our living rooms and bedrooms.



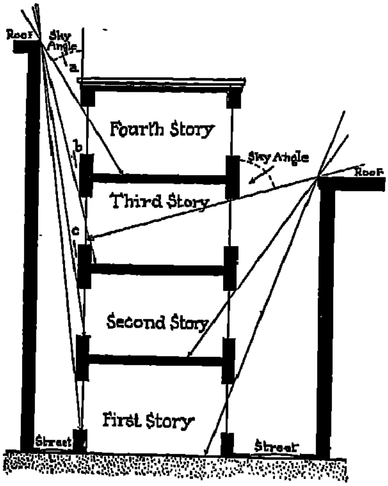
Courtesy General Electric Co.

Contrast the light here with the picture on the opposite page. The intensity of light here is 10,000 foot candles.

Courtesy General Electric Co.

The intensity of light here is 10 foot candles. Do you think this is sufficient illumination? How can the eye adjust itself to such widely different intensities of light?

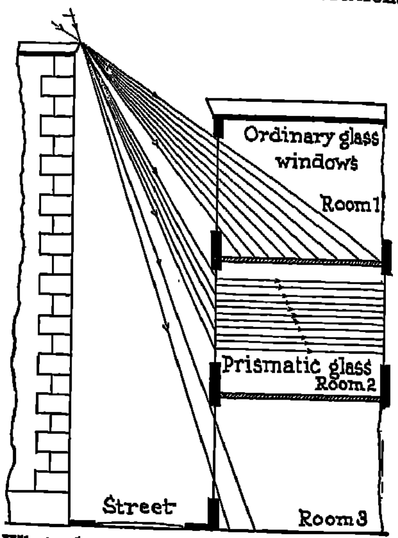
Control of Sunlight in a House. Good house planning demands that an area equal to $\frac{1}{4}$ to $\frac{1}{8}$ of the floor space be given to the windows, and that a house should also be placed so that living rooms and bedrooms get some direct sunlight. Bedrooms may have an area less than $\frac{1}{4}$ of the floor space devoted to windows, but should not have window hangings and draperies because they catch dust and bacteria, and also cut off some air. The wall paper and woodwork ought to be light in bedrooms, and the wall coverings should be smooth so as not to collect dust. As a rule the ceiling should be lightest, the walls a little darker, and the floor still darker to get a good distribution of light in the room. White walls reflect 76 per cent of the light, brown walls only 22 per cent, while olive green walls reflect only 14 per cent. The amount of light entering the room can be adjusted by shades, blinds,



Which side of this building will have better lighting and why?

or awnings. The Venetian, or porch blind, is a convenient type as it cuts off the sun's rays without preventing circulation of air.

Light in the City Home. It has been found that only 10 per cent of sky light passes through a window if the light strikes it at an angle of 10 degrees, while 90 per cent goes through if light strikes it at an angle of 90 degrees. In buildings on narrow streets the angle at which light strikes the windows is an important consideration. Tall buildings cut off direct sky light and cause the light that reaches the windows to come at such an angle that very little comes through. The color of surrounding buildings is also an important factor. If a near-by building is of red brick or dark stone, it will reflect but little light, while a white building will reflect a large amount. Smoke and fog may cut off much light, especially in winter.



What advantages does room 2 have over the other rooms? Explain.

Light in lower rooms which are not favorably located can be increased many times by using either prism glass or ribbed glass. This glass refracts the sky light and gives it to the room as seen in the illustration. (See room 2.)

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

over	tall	sun	indirectly
under	keep	harmful	direct
sky	pass	beneficial	above
lowest	light	greater	moon
less	directly	across	stars

The (1)____ we get from the sky is really light coming to us (2)___ from the (3)____. Some (4)____ sunlight is (5)____ to man. The greater the angle between a ray of light and a window-pane the (6)____ the amount of light which passes through. In cities, (7)____ buildings may (8)____ much light from the (9)____ from entering the windows of the (10)____ apartments.

ESSAY TEST

Victor Has Lived in a Tall Apartment House

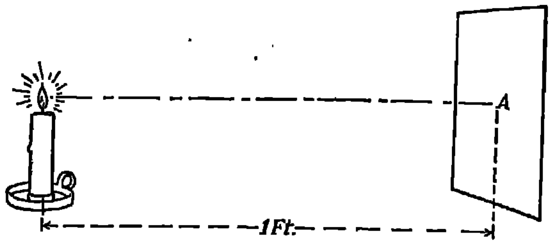
Read carefully and critically. List all the errors and suggest corrections.

Daylight in an apartment house is quite different from that in a single house in the country. In the first place, the sun never shines into any apartment in a large city. All the daylight one gets is sky light. Light from the sky is only $\frac{1}{4}$ as bright as sunlight and for that reason apartments are dark. Some rooms in our apartment do not even get any sky-light, we have to use artificial light there all the time. There is no way of improving the lighting of rooms on the lower floors of tall apartment houses.

PROBLEM II. HOW DO WE SECURE GOOD ARTIFICIAL LIGHTING?

How We Measure Intensity of Illumination. A good many years ago scientists began to measure the intensity

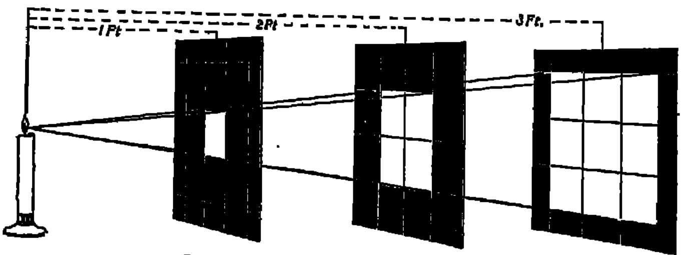
or brightness of a light in units of *candle power*. The standard candle agreed upon was a sperm candle which



What unit does this cut show?

burned at the rate of 120 grains per hour. This unit is still used to measure intensities of lights. It is not so much the *brightness* of our light at its *source* as it is the *amount* of *illumination* upon our book or our work that is important. In order to measure illumination, the *foot candle* unit has been agreed upon. A foot candle is the intensity of illumination given by a standard candle at a distance of one foot. If the light falling upon this page equals that given by six standard candles one foot away, the illumination is six foot candles.

Intensity of Illumination and Distance. Have you noticed that the intensity of light on the page of a book varies with the distance from the lamp which gives the

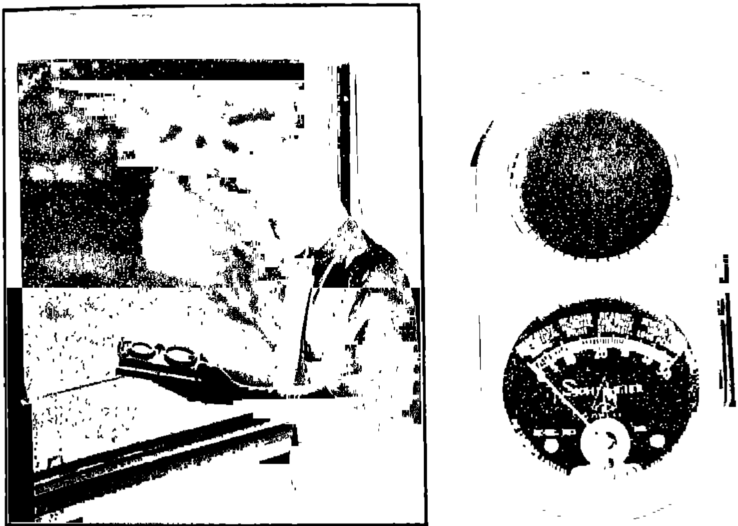


What law does this cut illustrate?

light? Light travels in straight lines, and therefore when it passes from a point through a one-inch-square opening

at one foot distance, it will cover an area two inches high and two inches wide, or an area of four square inches at a distance of two feet from the light. On one square inch at the two-foot distance there will be only one fourth the amount of light. Therefore, if we double the distance from the light, the intensity of illumination will be one-fourth as great, and at three times the distance, the illumination will be one ninth as great. This principle may be stated as a Law of Inverse Squares: *Other conditions being equal, the intensity of illumination upon any surface varies inversely as the square of its distance from the light.*

How Much Illumination Is Needed. We have seen that the iris acts like the diaphragm in front of the camera lens. It cuts off light or lets more in, depending on the time of day and the intensity of light. For reading, writing, or housework, three to six or more foot candles are desirable. If we are sewing on white goods, eight



Courtesy General Electric Co.

By means of the sight meter it is possible to determine the exact intensity of illumination we are using.

foot candles are needed, but on dark materials, twelve or more foot candles are required. The amount of light needed in a given room will vary from time to time according to our use of the light. The amount of light on a given surface can easily be tested by means of a simple instrument known as a foot-candle meter. The following table may suggest acceptable illuminations for your home.

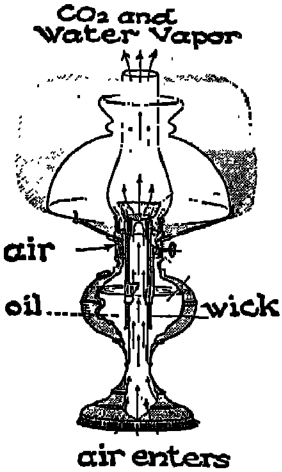
	Desirable	Minimum
Hall and stairways .	2 to 2.5 foot candles	1 foot candle
Living and dining-room	4 to 8.0 foot candles	2 foot candles
Sewing room . . .	8 to 15.0 foot candles	5 foot candles

The illumination in foot candles recommended for use in schools is as follows: assembly room, 4 to 6; classroom, study room, and office, 5–10; cloakroom, 2–4; corridor, 1–2; drawing, 10–20; laboratory and manual training, 8–12.

What Power of Light to Use. Suppose you need four foot candles of illumination for work five feet from the source of light, what power light is required? A four-candle-power lamp gives four foot candles at a distance of one foot, but according to the law of inverse squares, only $\frac{1}{25}$ as much at five-foot distance. There we need 25 times as much light, or a 100-candle-power lamp, to give the required illumination. A 100-watt electric tungsten lamp will give 100 candle power, but because low-powered lamps are less efficient, four 25-watt lamps will give a total of only 80 candle power. Nevertheless, in some rooms the light of the four lamps well distributed may give better general lighting to the room than the single lamp.

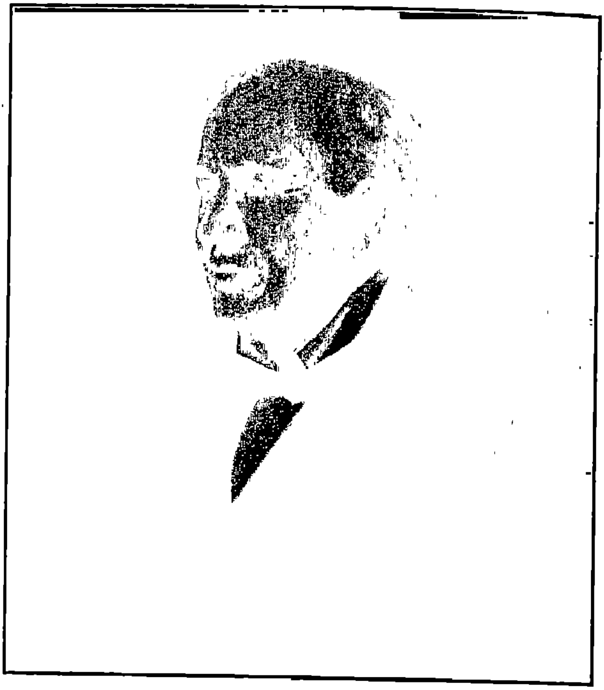
Best Sources of Artificial Light. A generation ago we would have mentioned oil and gas as important, but today electricity is king. A good many country homes

not connected with power still use kerosene lamps. Of these the type with the circular burner, the Argand type, gives the best light. Gas has been given up almost entirely except in a few communities where natural gas is cheap. Here the Welsbach mantle is used to give a white light. The camp lamp which uses kerosene or gasoline under pressure sprayed into a Welsbach burner gives a steady light not influenced by wind and rain. This type of light is used in many isolated homes. With the development of the incandescent light, electricity has become the most used illuminant in our homes.



Explain why this lamp burns without smoking.

Tungsten Lamps. We have two types of electric lamps today, the vacuum and the gas-filled. The tungsten filament placed in bulbs gradually throws off particles of vapor which you all have seen in the darkened color of an old bulb. The higher the temperature the greater the amount of vaporization of the tungsten. But the higher the temperature in the bulb the greater is the quantity of electric energy changed to light. The presence of nitrogen or argon gas in the bulb exerts pressure on the filament, thus reducing its vaporization. This allows operation of the light at a higher temperature and increases the efficiency of the lamps. The vacuum-type lamp changes 7 per cent of the electrical energy into light while the gas-filled type changes 10 per cent. The higher the temperature at which the lamp is operated, the whiter the light. The photoflood lamps now used to take indoor photographs are operated at much higher temperatures

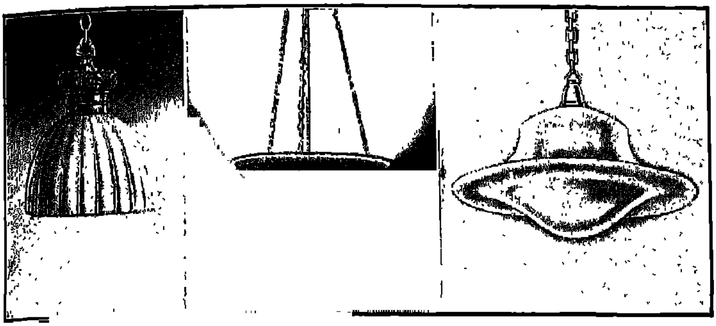


THOMAS ALVA EDISON, 1847-1931

BORN in a little town in Ohio, Edison as a boy showed little promise of what he was to be. He was, however, always busy, and a great reader. At the age of 12 during the Civil War, he was a train boy on the Grand Trunk Railroad, and published a small paper which was mentioned by the *London Times* as being the only newspaper ever printed on a train. At 16 years of age, he learned telegraphy, and became a telegraph operator. From this time his career of invention began. He soon had improved methods of sending telegrams, his most important invention being a quadruplex system, by means of which messages could be sent in both directions at the same time. At the age of 21, he had invented a machine that, with improvements, later became our stock market ticker. He invented the phonograph, the microphone, the battery used in the electric automobile and various improvements in electrical engineering. But we remember him best as the Wizard of Menlo Park, and the inventor of the incandescent electric light. An inveterate worker, in spite of his handicap of deafness, he became the most successful and best known inventor of his time.

than our ordinary bulbs, and for this reason they are short-lived.

Methods of Lighting. Several methods are used in lighting the home. In direct lighting, the light is thrown



Direct lighting — Indirect lighting — Semi-indirect lighting

Which of the three methods do you consider best for your living room? For the kitchen? For a schoolroom?

from the lamp or a reflector to the place where it will be used. Direct lighting is economical because little light is lost through diffusion or absorption, but it causes a glare. In indirect lighting, an opaque reflector throws the light rays upward against a white or light-colored ceiling from which the light is diffused through the room. It is not an economical method, but very restful to the eyes. In semi-indirect lighting, a globe for the lower half of the light is made of frosted glass, capable of reflecting and diffusing light, while the upper part of the globe has clear glass through which light passes to the ceiling and is diffused throughout the room. This is probably the best method of lighting for most work.

Concealed Light Sources. If one does not need to consider the cost, an indirect lighting system in which all units are concealed will give pleasing results. Many modern houses are now being built with recesses in the walls or ceiling so that lamps may be placed out of

sight and light reflected into the room or radiated through diffusing glass. Such lighting often gives very beautiful effects in a room because of the very even illumination obtained.

Danger from Glare. When the source of light is so placed that direct light shines into the eyes, the iris con-

Which of these positions is better for the eyes and why?

tracts so as to protect the eye and may cut off so much light that eyestrain results, and with it headaches and possibly other disturbances. Smooth paper or smooth shiny surfaces may have the same effect. The position in which one holds a book in reading is of much importance because of the possibility of glare. Flickering light causes eyestrain by calling upon the eye for continual readjustment. This is the reason we should not read in such a light or when traveling in railroad trains or autos.

SELF-TESTING EXERCISE

Select from the following list those words which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

direct	half	cooled	illumination
indirect	boil	heated	power
semi-indirect	vaporize	three	more
higher	six	foot	most
lower	two	fourth	candle

The unit for measuring brightness of a light is (1)____ (2)____. The unit for measuring the intensity of illumination is the (3)____ (4)____. If I move from 3 feet to 6 feet from a light, I shall get only one (5)____ as much (6)____. Gas-filled lamps are (7)____ efficient than vacuum lamps because the filament in them can be (8)____ to a (9)____ temperature and not (10)____. Of the (11)____ important methods of electric lighting, the (12)____ is most economical, but the (13)____ is best for general lighting.

ESSAY TEST

Agnes Tells of Lighting in Her Home

Read carefully and critically. List all the errors and suggest corrections.

We have electric lights in our house — some 60-watt vacuum and some 60-watt gas-filled lamps. But all 60-watt lamps give the same amount of light.

I find that a 60-watt lamp gives me plenty of light 3 feet from it but at 6 feet from it I get only half as much light and that is not enough as I have found by experience. In the dining room we use the indirect lighting with a single large lamp hanging down over the center of the table. I find that I can study perfectly well when facing a 100-watt frosted lamp. It is quite easy to understand this: the bright light closes the iris so that not enough light can get in the eye to harm it.

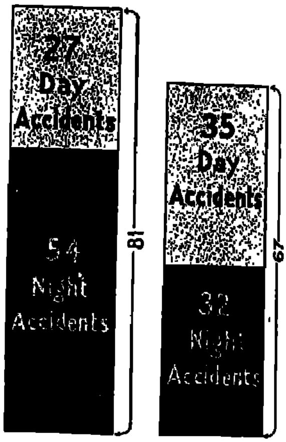
PROBLEM III. WHAT LIGHTING IS DONE BY THE COMMUNITY?

Reasons for Lighting Streets. Anyone who has had to go through the dark streets of some area in a town in which the lighting was poor, and who has compared this experience with that of walking on a modern "main street," knows that there are good reasons for street lighting. Good illumination results in increased and safer traffic, more trade in the stores, greater property value, decrease in crime, and decrease in accidents. A large insurance company recently made a survey of 46 cities having a population of over 25,000,000. Out of this number, 392 fatal and 10,177 non-fatal accidents in these cities were found to be due to inadequate street

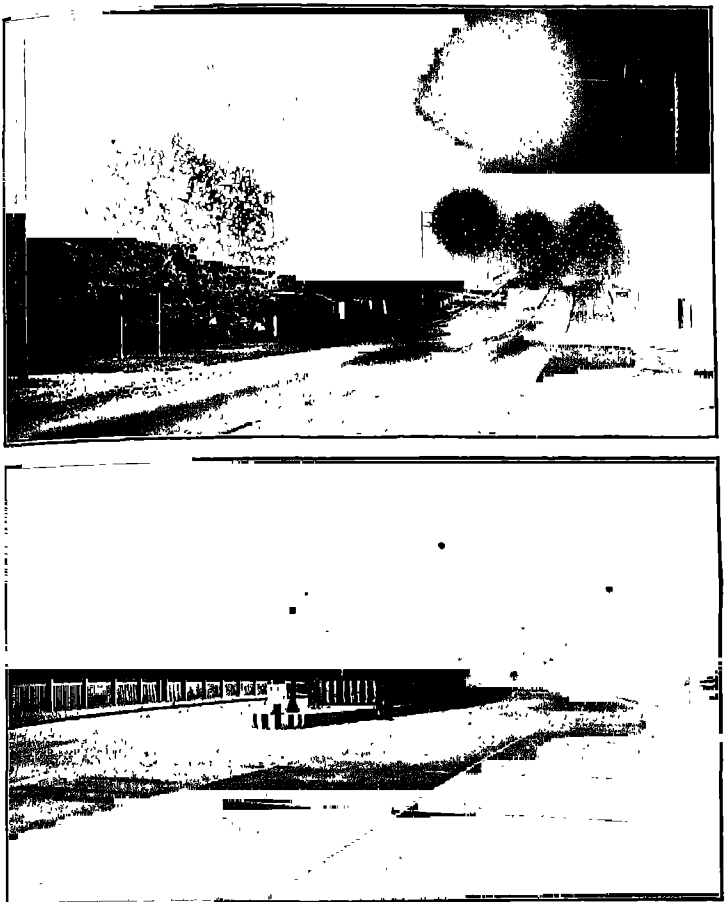
lighting. Detroit attempted to save money recently during the depression by cutting out 2000 street lights and dimming others 30 per cent. At the end of 10 months, daytime traffic accidents had *decreased* 22 per cent, while night traffic accidents *increased* 23.3 per cent. Similar results were obtained from San Francisco, Chicago, and other cities. Not only did traffic accidents increase with poorly lighted streets, but crime also increased to a very great extent. In 1931, San Francisco improved the lighting of 3 miles of Bay Shore Boulevard. As a result night accidents there decreased 40 per cent. Several authorities claim an economic saving of $100,000,000 a year might come from the increased lighting of streets, which would bring about a decrease in crime and traffic accidents.

After 10 months of poorly lighted streets Detroit had this result.

What Constitutes Good Street Lighting. Some of the earliest light came from electric lamps placed on tall poles. These gave a faint light over a large area. Then came a period of arc lighting in which there were spaces of intense light and spaces of much darkness in the street. The best street lighting is that where the illumination is quite even with no deep shadows and with absence of glare. Reflectors



The results on the Bay Shore Boulevard, San Francisco, before and after lighting.

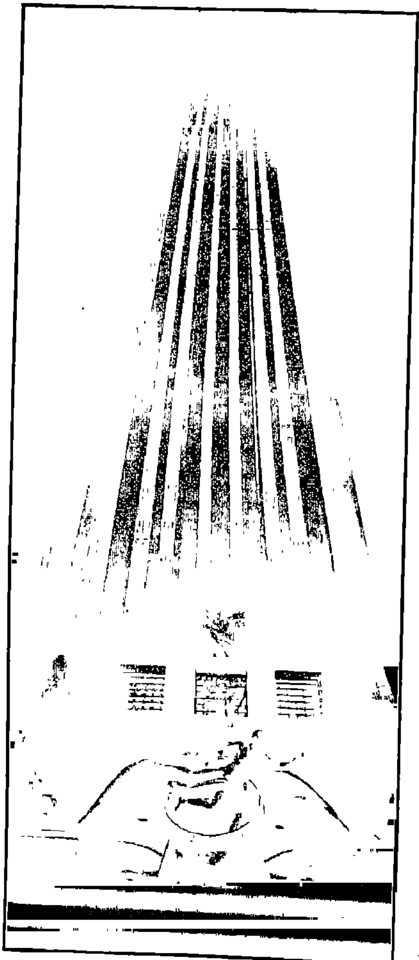


Courtesy General Electric Co.

Two types of street lighting. Which do you consider better for night driving and why?

which spread the light in ovals instead of circles along the street give greater efficiency and effectiveness in lighting. Business streets outside of window and sign lighting should have 1 to 2 foot candles and the residential section $\frac{1}{4}$ to 1 foot candle. In the country, the present standard of street illumination is only 0.05 to

0.2 foot candles. In densely populated areas electric wires should be kept under ground in conduits, as are telephone wires. These underground cables prevent broken wires in storms and also make for beauty.



Wendell McRae

This interesting picture was made by pointing the camera toward the top of this building 70 stories or 852 feet high. How far is it illuminated by the flood lights? Where would these lights be placed?

Beauty a Detail in Street Lighting. While efficiency and utility should be first considerations, modern communities also must consider beauty as well. Ornamental fixtures cost little more than ugly ones and may give the city enough attractiveness to repay in a financial way the extra cost. Compare a city street in which the wires are overhead and the fixtures plain and ugly with the street where ornamental stands are used with a group system of lighting and underground wires. In many towns the value of property along streets properly lighted increased 50 per

cent after the introduction of adequate and ornamental street lights.

Flood Lights. In late years flood lights have been used particularly to show off beautiful buildings and public monuments. The flood lighting of such buildings as the Empire State Building, Radio City, or the Pasadena City Hall, and hundreds of others in this country, gives economic as well as aesthetic value. Flood lights are also used in parks and athletic fields for night games. The Wrigley field in Los Angeles, used for night baseball and football, has 144 flood lights, giving an illumination of 40,000,000 candle power.

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

beautiful	common	beauty	community
ugly	crime	accidents	attention
water	government	person	asset
gas	money	business	regular
post	design	fixtures	decreases
increases	oil	wires	harmful

Good street lighting is an (1)____ to any (2)____ because it (3)____ traffic (4)____, reduces (5)____, and increases (6)____. Before electric lighting was so (7)____ many cities used (8)____ for lighting the streets and before that (9)____ lamps were used. Much (10)____ is given today to the (11)____ of lamps and lamp-posts. The lighting (12)____ may just as well be objects of (13)____ as to be unsightly or (14)____ in appearance.

ESSAY TEST

WILL EZRA BE A LIGHTING ENGINEER SOME DAY?

Read carefully and critically. List all the errors and suggest corrections.

I have read a good deal about street lighting. People were once required to light the street in cities by hanging burning candles on

poles from their windows. Oil lamps on posts came next. These could not be depended on if the wind blew as the lights would go out. Gas was then used, but if the gas flame was blown out people would be poisoned by the escaping gas. Then came electricity, but the use of individual lights on posts at intervals makes it very light near the lights and very dark between them. Besides if there are shade trees along the street, the lights will be of very little use. Modern lighting will sometime find application on our streets. I would suggest a long glass tube be centered over the streets and run the length of our streets. These tubes can be made to give out light just as the tubes in advertising signs do, but they should give white rather than red or blue light and the tubes should be larger. This would give an even distribution of light.

THE REVIEW SUMMARY

In preparing a summary of what you have found out in this unit, you will want to place emphasis on the big ideas which have come from the applications of the facts you have learned and the demonstrations you have seen. Doubtless you have done some additional reading which has helped you put together some of the facts into generalizations or fundamental underlying principles. For this unit some of these generalizations are:

1. The sky is an important source of natural light.
2. The illumination we receive depends upon the brightness of the source of light and our distance from it.
3. A glare of light produces eye strain.
4. Street lighting and flood lighting are valuable assets to any community.

Before making your review summary for your workbook, test your knowledge of the facts of the unit by checking over the text so as to be sure you know the facts underlying the science principles or generalizations. Then using this material and everything you have read, seen, or done yourself, make your summary outline. This outline you may use when you make a recitation.

TEST ON FUNDAMENTAL CONCEPTS

In a vertical column under the heading CORRECT *write numbers of all statements you believe are true. In another column under*

INCORRECT *write numbers of the false statements. Your grade = right answers* × $3\frac{1}{3}$.

I. **The sky gives light because:** (1) the particles of air give out light; (2) dust particles reflect and diffuse sunlight; (3) small particles of moisture diffuse light; (4) air is transparent; (5) there is nothing to hinder it from doing so.

II. **Sunlight in the home may be controlled by:** (6) the location of the study desk; (7) the size of the window; (8) the number of people using the light; (9) window shades and curtains; (10) color of the walls of the room or of adjacent buildings.

III. **The illumination on my book varies with:** (11) the candle power of the source of light; (12) the number of foot candles needed; (13) my distance from the light; (14) kinds of paper used in the book; (15) size of opening in the iris of my eye.

IV. **Artificial light is diffused by:** (16) frosted bulbs; (17) mirror reflectors; (18) opaque indirect lighting reflectors; (19) opal globes surrounding the lighting bulb; (20) clear glass globes surrounding the bulb.

V. **Glare is caused by:** (21) a bare light in the field of vision; (22) facing a window when reading; (23) holding the paper or book so that the strongest reflected rays enter the eyes; (24) glossy paint and polished metals; (25) not using your eyeglasses.

VI. **Street lights:** (26) are absent on many country roads; (27) are necessary in large communities; (28) must be brighter on most country roads to eliminate danger to pedestrians from automobiles; (29) can often be made more effective by use of proper reflectors; (30) generally cost a community more than they are worth.

PRACTICAL PROBLEMS

1. List the various devices in your home that have to do with the production of light. Explain how the need of light determines their use.

2. You are reading by daylight in a north room in winter and using a reading glass. Tell all the changes through which the rays of light pass from the time they leave the sun until they give you the sensation of light in your brain.

3. Describe how you would arrange ideal lighting for the desk at which you study at night. Consider the problem from the standpoint of care of your eyes as well as the best possible arrangement of lighting fixtures.

4. Make a survey of the lighting in your home. Give several practical suggestions for additions or changes in the lighting fixtures in the rooms. Your suggestions must be practical to be worth anything and must take into account the present conditions.

INTERESTING THINGS TO DO, READ ABOUT, OR SEE

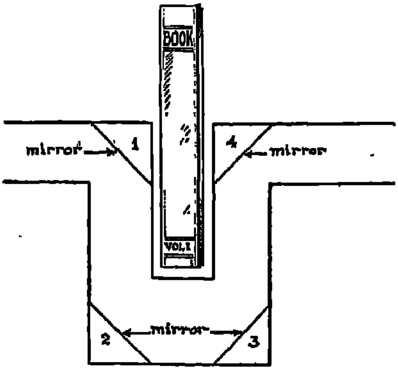
1. Read a book on the life of Edison.
2. Visit a factory where incandescent lamps are made.
3. What makes the light in different kinds of lighting devices?
4. Natural animal light: the firefly, phosphorescence in the water and in deep-sea animals.
5. Natural lights seen in the sky: give the source and explanation of: sunlight, sky light, light of shooting stars, rainbow, sunset color, lightning, northern lights, sun dog, and St. Elmo's fire.

SCIENCE FOR LEISURE TIME

1. The Home Lights

Make a plan of the rooms; locate the lamps in each room; record the number of watts in each lamp. Calculate the distance you should be from a given lamp or cluster of lamps to give you satisfactory light for a specific kind of work. Assume that the lamps have the following candle powers.

25 watts . . .	20 c. p.
40 watts . . .	35 c. p.
60 watts . . .	50 c. p.
75 watts . . .	65 c. p.
100 watts . . .	100 c. p.



2. The sectional diagram will suggest how you can construct a rack inside a box to hold a book and how to arrange 4 right-angle prisms or 4 mirrors (1, 2, 3, and 4) so that you appear to look right through the opaque object and see objects that are behind it. Can you explain the illusion?

3. Lamps through the Ages

Make a scrapbook in which you use clippings, diagrams, and descriptions of lamps of all time. Begin with the oldest you can find out about and arrange material in chronological order.

4. Make a Current-Science Book of Lighting

In this use clippings, pictures, and descriptive matter that have to do with present-day lighting for any purpose.

SCIENCE CLUB ACTIVITIES

1. Invention of the Incandescent Lamp

Prepare an Edison Day program. Assign to different members various topics, for example, Early Life of Edison, Menlo Park, Experiments in Developing a Lamp Filament, Other Inventions of Edison, Improvements in the Lamp by Others.

2. Community Street Lighting

Assign jobs to different committees for reports at a future meeting. (1) The source — a visit to the gas plant or to the electric light plant or reading about oil wells if oil lamps are used. (2) A survey of the lighting of streets in the business section. (3) A survey of street lighting in the residential section. (4) A survey of street lighting in the rural section. Kinds of lighting; how satisfactory are results; suggestions for improvement.

3. History of Lighting

Members may bring old lamps to the club and tell about them. If the local museum has a good display, the club should arrange a trip and get someone familiar with the history of lighting to tell about them. Often there will be found someone in your community who has made a hobby of collecting old lamps. Arrange to have him exhibit his lamps and talk to the club about them.

REFERENCE READING

Book of Popular Science. Grolier Soc., 1924.
Compton's Pictured Encyclopedia.
Luckiesh, M., *Artificial Light.* The Century Co., 1920.
Reiser, O. L., *The Alchemy of Light and Color.* Norton, 1928.
Stair, S. L., *The Lighting Book.* Curtis Lighting, Inc., Chicago, 1930.
Whitman, W. G., *Household Physics.* Wiley, 1932. Natural light, p. 292; artificial lighting, p. 310; illumination, p. 322.

Survey Questions

Do you know if an electric current can produce magnetism?
How are electromagnets made?
What is a magnetic field?
Do you know why a compass needle points north?
How does the electric motor work?
Can you tell how an electric iron gets its heat?
Do you know how an electric bell works?
What are fuses and for what used?
Under what conditions is electricity dangerous?
Of what value are insulation materials?

Westinghouse

UNIT VII

HOW WE USE ELECTRICITY

PREVIEW

Electricity has been called a most versatile servant. A versatile person is one who can do many things well, so this is certainly a good title. Electricity does so many different things well for man that it is hard to think of a process or a manufacture that it does not have a part in. It lights our homes, our street, mines, tunnels, airships, and submarines. It even lights our way on the roads on a dark night, perhaps in the form of lightning from an oncoming storm, perhaps from a "flashlight" in our hand. Electricity runs our trains and ships. It still runs some automobiles entirely, and plays a very important part in running all of them. Very few types of gas engines can run without the use of an electric spark to ignite the charge of gas in the cylinders. In the form of motors, we find it turning the wheels of great factories, and it is found in the home harnessed to washing machines, to the vacuum cleaner, sewing machine, electric refrigerator, and many other devices.

In industry it plays a part in thousands of processes: it plates some metals with silver, gold, or copper; it hammers some of those same metals into strips or plates; it operates drills which bore holes or gouge out great hollows in solid blocks of metal. By means of electromagnets of the electric crane it lifts great weights, carries them a distance, and then drops them at the turn of a switch. It drives many kinds of machines and does it

without dust or smoke. It carries messages for us through wires and through space. It transfers sound, music, and pictures from one place to another thousands of miles away.

Today we are just beginning to learn what electricity is, but it is not yet completely understood. How electricity is made, what it will do, and how it can be used safely are well-known facts, and it is about these things that this unit is written. It was not until the latter part of the eighteenth century that Volta, an Italian physicist, produced a current of electricity from the first electric cell which he made and which was called after him the voltaic pile. But it was only as recently as 1831 that Faraday, an Englishman, produced an electric current with the first generator, a coil of wire surrounding a horseshoe magnet. Edison, who has probably done more than any other one man in electricity, took out more than 1100 patents on various electrical devices in the United States during his lifetime.

There are a few facts and principles that you should recall from your last year's science work, since they are important as a foundation for the work in this unit.

Science Principles

1. The earth's magnetic field directs the compass needle.

2. Comparatively few metals can be made into magnets or are affected by magnets.

3. Like poles of magnets repel; unlike poles attract each other.

4. Electricity consists of negative electrons and positive protons.

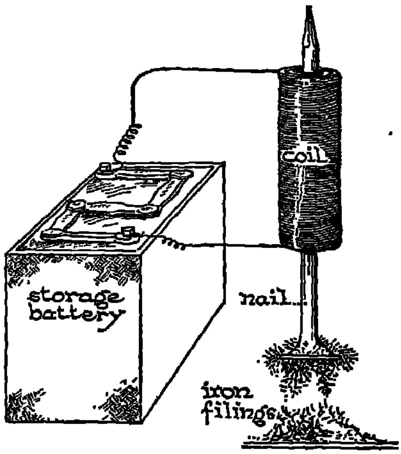
5. Chemical energy and mechanical energy are readily transformed into electrical energy, which in turn can be transformed into all other forms of energy.

PROBLEM I. WHAT ARE ELECTROMAGNETS AND HOW ARE THEY USED?

How to Make a Magnet. A little over a hundred years ago a Danish professor named Oersted discovered that when electricity was made to flow through a wire, as long as the electricity continued to flow the wire would act like a magnet. The following experiment shows how magnets are made.

Demonstration 1. How to Magnetize Steel.

Wind a sheet of paper, 6 inches long, about a pencil. Loosen your hold on the paper tube and let it unwind until it is $\frac{1}{2}''$ in diameter. Wind about this tube forty to fifty feet of #20 or #22 insulated copper wire. Fasten the ends of the wire so that they will not unwind. Place in the tube the articles you wish to magnetize, a knife, knitting needles, nail file, or a piece of steel. Now connect the two ends of the wire with the opposite poles of an automobile battery. After a very short exposure to the current the articles will be found to be magnets.



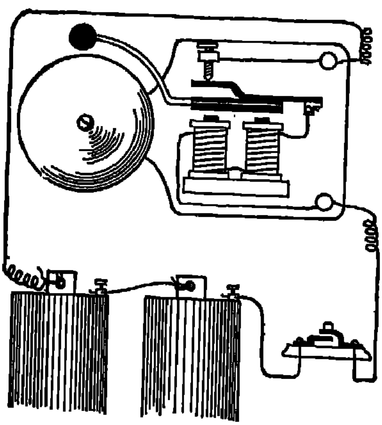
The Electromagnet and Its Uses. An electromagnet is made in this way. Place inside the coil of wire carrying a current, a nail or any bar of soft iron and you have an electromagnet. In general the strength of an electromagnet is increased as the current of electricity passing through it is increased. The advantages of an electromagnet over a permanent magnet are twofold. It can be made to lose its magnetism in a fraction of a second. By alternately magnetizing and demagnetizing a soft iron bar, an interrupted or vibrating motion may be

produced. This vibrating motion is used in giving motion to the electric buzzer, in the ringing of school gongs and fire alarms, in telephone and telegraph instruments, and in the electric bell which we use every day.

Demonstration 2. To Demonstrate the Electric Bell.

Materials. Electric bell. Electric cells. Wires. Push button.

Method. (*A*) Study the bell. Make out these parts: two binding posts, electromagnet, armature, spring, contact post, contact screw, hammer, gong. Trace the wire connection through the different parts from one binding post to the other.



Note. In some bells a part of the wire circuit is omitted, and the base of the bell carries the current from one part of the bell to one of the binding posts. Is that the case with the bell in hand?

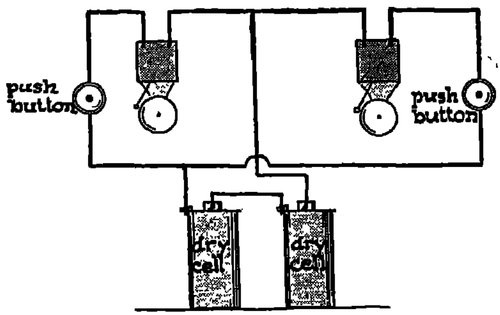
Connect bell, cells, and button in circuit. Adjust contact screw if necessary. Make the bell ring.

Explanation. Explain in detail just why the bell rings. Make diagram and trace, using arrows, the passage of the current through a complete circuit.

The Electric Bell. The working of an electric bell depends upon the principle of attraction by an electromagnet. The common electric bell has a U-shaped electromagnet. In front of the poles is a bar of soft iron, called the armature, joined to a spring at one end and having a hammer for striking a gong attached to the other. A post on the opposite side of the armature from the magnet has a screw whose point touches a spring attached to the armature. When wires from a battery are joined to the binding posts of the bell, and the button is pressed to close the circuit, the current flows to the post

and contact screw through the armature spring, around the electromagnets, and back to the battery. When the current is flowing, the magnetic force pulls the armature, which draws the hammer over to strike the gong. At the same instant the circuit is broken at the end of the contact screw, the current stops, the magnetic field disappears, and the armature springs back to its original position. As long as one's finger is on the button, the circuit is closed and the operation continues to be repeated.

Explain why the bell rings only when the current is flowing.



Two independent bell circuits operated on the same battery. One bell rings from one button. What changes would you make to have both bells ring when one button is pressed?

House Bell Circuits. It is frequently desirable to have a single bell rung from two different parts of the house, to have two bells in different places rung from the same button, or to have two bells each rung from different buttons, but using the same battery or transformer. The diagram shows how one of these combinations is made. Can you make the others?

If the bell does not ring, look for trouble in worn-out cells, short circuit where metal straps hold the live wires, loose connections, or improperly adjusted contact screw.

How the Electric Motor Makes Use of Electromagnets. The essential parts of a motor are the field magnets, the armature, the commutator, and the brushes. In Figure 1, the two unlike poles of a horseshoe magnet, *A* and *B*, are a few inches apart, and another magnet *C* is arranged on a pivot between them. If we turn the magnet *C* so that

its north pole is near the north pole, A, and its south near the south pole, B, we find that it rotates until the south pole of C is near the north pole, A. If we could now change the polarity of C so that its south became a north and its north a south, then the law which says that like poles repel and unlike poles attract would send it another half revolution in the direction it was going. If the polarity of C could be reversed every half revolution, this movement would be continued. In Figure 2, the electromagnet M may have its polarity reversed by merely changing the direction of the current in the wire. This coil M rotates in a strong magnetic field produced by the field magnets A and B. D and E are fixed brushes which carry the current through the commutator to the armature. The commutator is the device which reverses the current in the armature. The current comes to D,

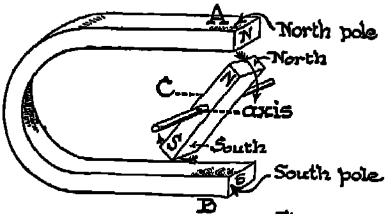


Fig. 1

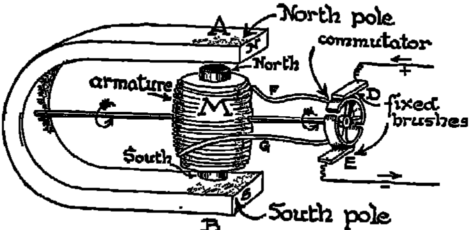


Fig. 2

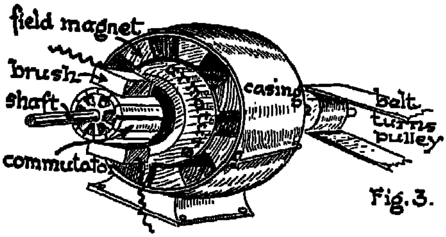
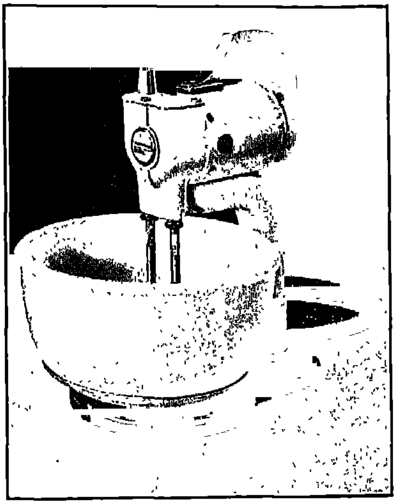


Fig. 3.

Study your text and the two upper diagrams carefully and then try to explain how the electric motor works.

passes through the coil of wire of the rotating electromagnet *M*, and passes off through *E*. The ends of the coil of wire of the electromagnets are attached to two metal parts of the commutator, which are insulated from each other. During one half the revolution *D* is in contact with *F*, and during the other half revolution it is in contact with *G*. When a north pole of the revolving electromagnet *M* (the armature) has reached the south pole of the field magnet, the current is automatically changed, and what was the north pole becomes the south pole. In order to make the action stronger, the magnet *A* and *B* may be replaced by an electromagnet. We have then the essential parts of the commercial electric motor.

Some Devices That Use Electromagnets or Motors. Home life would not be complete without a good many devices that make use of electromagnets. Not only does the electromagnet ring our doorbells and elevator bells, but it is a necessary part of our fire alarm boxes, burglar alarms, and railroad and traffic signals. In the motor it runs our trolley cars and subway trains, it gives the spark necessary to start the engines in our motor cars and busses. It helps run our meat grinders, cake mixers, vacuum cleaners, washing machines, sewing machines, dish washers, ice-cream freezers, electric fans, and the many other labor-saving devices of the home. In the barber shop you find



What household devices not named in the text are run by electricity?

it in the hair clipper, in the drug store it helps make you a milk shake, and in the meat market it slices meat.

SELF-TESTING EXERCISE

Select from the following list of words those which best fit the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

force	closed	magnet	armature
magnetism	electrical	energy	opened
electricity	field	current	compass
mechanical	poles	magnetic	heat

Every wire carrying an electric (1)____ is surrounded by a (2)____ (3)____. Because of this a coil of wire will appear like a (4)____ having both north and south (5)____. The operation of the electric bell depends upon the (6)____ motion produced by the pull of the electromagnet upon the (7)____ and the release of the armature by having the circuit automatically (8)____ after every pull. An electric motor receives (9)____ energy and gives out (10)____ energy. The action of the motor depends upon the laws of (11)____ poles.

ESSAY TEST

Riley Experiments with His Electromagnet

Read carefully and critically. List all the errors and suggest corrections.

I took the barrel of an old fountain pen, cut off the ends so I had a tube open at both ends. I wound about 250 turns of insulated wire around this. I tied the wires with string so they would not unwind, leaving 2 feet of free wire at the ends. I connected one of these ends to the carbon of a dry cell, joined 3 cells, unlike poles together. The other end of the wire from the coil and a wire from the zinc of the battery were joined to a push button. I put one end of the coil into iron filings, closed the circuit and as I lifted the coil the filings clung to it. This was because the hard rubber had been magnetized. I put a long nail half inside the vertical coil, closed the circuit, nothing happened. I closed the circuit and brought one end near the north end of a compass needle which was attracted. By that I knew the end near the compass was the north end of the electromagnet.

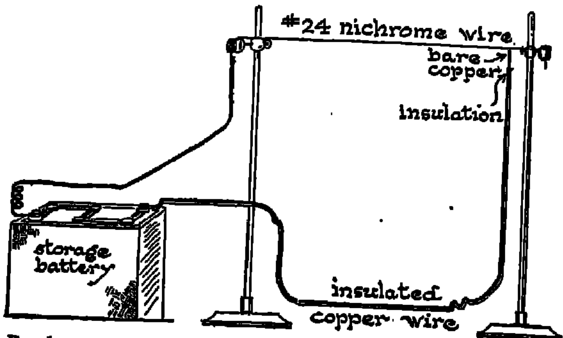
PROBLEM II. HOW IS ELECTRICITY USED IN HEATING?

Electric Heating. Heat from electricity is always ready, always clean, and always convenient. It is therefore used in many electric devices in the home. For example, the electric iron is one of the most used instruments in the home. Various table devices such as toasters, grills, coffee percolators, chafing dishes, samovars, and plate warmers are also electrically heated. The small disk stoves and the water and milk warmers now on the market use electricity. The curling iron and hair drier are also often seen, while we all know the comforts of the electric heating pad and the glowing electric heater. The electric range has come into common use in many sections of the country, especially where there is a low rate for electricity. In some homes electricity is now used for heating the entire house on the unit system, but such a form of heating is not very well adapted to cold climates.

Electric heating in many places is very expensive. But to make up for this it is very efficient. There are no combustion losses. There are no chimneys, smoke, or ashes to look out for, no space is needed to store fuel, and above all, it is absolutely clean. The actual cost of installation is as low as in any of the other modern systems of heating a house, but the cost of maintaining the service makes it prohibitive for common use except in regions where electricity is very cheap.

How Electricity Produces Heat. We have seen that electrical energy can be transformed into heat energy. This is done by the principle that all conductors resist the flow of electricity, and that when electrical energy overcomes this resistance, heat is produced. Some metals like German silver and nichrome, an alloy of nickel and chromium, offer much greater resistance to electricity than does copper. For this reason a short length of

nichrome wire will give as much heat as a much longer copper wire of the same diameter. You can easily show how we get heat from electricity by connecting one end of a 6-inch piece of #24 nichrome wire to one pole of a



Read your text carefully and then try to explain this diagram.

6-volt storage battery. Then bring the bare end of a copper wire from the other pole of the battery into contact with the free end of the nichrome wire. As you move the copper wire along the nichrome wire, shortening the length of wire through which the current flows, you will find that heat is produced and that the shorter the wire, the hotter it gets. If the current in a wire is doubled, the heat in it is increased four times. For this reason many devices get overheated, and fires are caused by carelessness with electric irons and other electrical devices.

In many electric devices which use heat, you will notice a coil of this nichrome wire which is heated to a red heat when the current passes through it. This is well shown in many electric toasters.

The Electric Iron. In the electric iron, the wire in position in the base of the flatiron is covered with an enamel which is baked on or it is held tightly between insulating material so that the wire cannot move out of position or touch other parts of the wire. This prevents

How many of these parts can you give the use of?

making a short circuit which would destroy the heating element. The electric iron should have a switch close to the iron, also a pilot light on the wall socket where it is attached. This pilot light will always glow when the current is left on and will warn you to turn it off before you leave.

SELF-TESTING EXERCISE

Select from the following list of words those which best fit the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

electrical	oxidize	conductor	heating
iron	high	insulator	greater
mercerize	poor	electric	nichrome
good	unchanged	electricity	German
low	changed	heat	silver

Every electric (1)____ offers some resistance to the flow of an (2)____ current. Overcoming the resistance in a conductor generates (3)____. The greater the current, other conditions being (4)____, the (5)____ the resulting heat. Copper is a (6)____ conductor of electricity and so is a (7)____ material with which to produce heat from (8)____. The wire used in many electrical (9)____ devices is (10)____, which has a very (11)____ melting point and does not (12)____ easily in air.

ESSAY TEST

Flora Tells about Her Interview with an Electric-Iron Salesman

Read carefully and critically. List all the errors and suggest corrections.

If I had never studied general science I might have believed a lot that he told me but before he left I told him he ought to learn a little more science so he wouldn't tell so many untruths. One advantage of his iron is that it can be taken apart. There are mica plates in it so you can look through it to see if the heating element is burned out. Thin bands or ribbons of aluminum are used in the heating element. They conduct more heat than nichrome and so give heat quicker. Many irons are shiny nickel but his is dull so it will not radiate and lose heat so quickly. He advised the old-fashioned iron without the thermostat because he said the thermostats are likely to burn out and cause a fire. I still like my adjustable, automatic, shiny, chromium-plated iron and even if it did cost more than his I believe it is worth the difference in original cost.

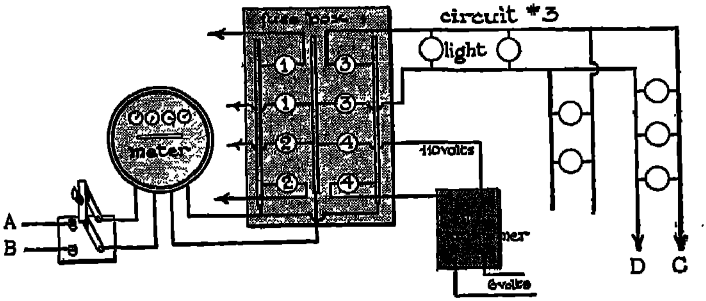
PROBLEM III. WHAT ARE THE SAFEGUARDS AGAINST HARM FROM ELECTRICITY?

How Electricity Is Led About in the Home. Although electricity has become a valuable servant, it is a dangerous one as well. We have often heard of fires that were caused by crossed wires making a "short circuit," or by accidents from electric wires of heating devices, or of people shocked to death by receiving a charge of electricity in their bodies. We know that the wires which carry electricity must be carefully guarded by a layer of what we call insulating material, that is, something that will not allow electricity to pass through it.

Conductors and Insulators. In order that water may pass through a metal pipe, there must be an open space within the pipe, but not so with electricity. In some mysterious way electricity passes along a solid metal just as well as along a hollow one. Scientists tell us that the

flow of electricity is merely the movement of the electrons which are present in the atoms. We find that there is a great difference in the ability of materials to carry electricity. Some, like copper, brass, silver, aluminum, graphite, and salt water, permit electricity to pass through them readily and are called good conductors. Others, like wood, earth, and pure water, carry electricity to a limited extent and are called poor conductors. But some materials, such as dry air, glass, porcelain, rubber, paraffin, mica, and silk, allow little or no electricity to pass through. Such substances are called insulators. Because metal wires carry electricity easily, and because human beings also might carry it, wires are insulated by a cover of cloth and rubber or other insulating material. This may prevent people from getting shocked to death.

What Is a "Short Circuit"? The circuit of electricity is the complete path which the current must take from its source through the wire, through the bell or other instrument, and back to its starting point. The rate of flow of electricity is measured in units called amperes, while the pressure the current exerts is measured in volts.



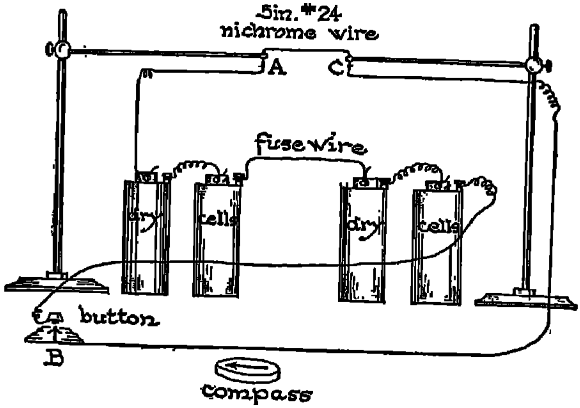
Under what conditions could you make a short circuit here?

In the diagram, *A* and *B* connect our house light with the city supply. When the switch is closed, we can light one or all of the lights in circuit #3. The filament of the

lamps checks the flow of electricity because it has a high resistance while the wires have a low resistance. Now suppose the bare ends of the wires *C* and *D*, which have low resistance, are brought together. This circuit would have no high resistance in it and thus would increase the current, causing a "short circuit." There is a real danger from short circuits, for they may not only burn the insulation off the wires, but may set the building on fire. If any part of the wire *AC* is connected metal to metal with any part of *BD*, or if the two separate metal parts of the lamp circuit be joined by a piece of metal, a short circuit results, with its great increase of heat and corresponding danger of fire.

Demonstration 3. The Use of Fuses.

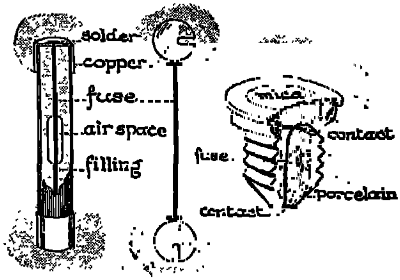
Join four dry cells in a circuit with a button switch and five inches of #24 nichrome wire as shown in the diagram. Between one pair of cells use a small fuse wire (3-ampere) in place of the regular copper wire.



1. Close the circuit by pressing the button. Is there evidence that anything happens? Bring the wire *BC* down near a compass needle and parallel to it. Press the button. Explain the result.

2. Replace the nichrome wire *AC* with large copper wire. Close the circuit. What results do you get? Explain.

Fuses. We have seen that metals melt at different temperatures, and some like lead and solder melt at relatively low temperatures. Such metals are used in making fuses. If a short circuit is made, the fuse instantly melts because electricity going through it heats it to its melting point, and electricity is immediately cut off from the house, and thus danger from fire is prevented. If a light goes out, remember before attempting to insert a new fuse in the fuse box to turn off the switch connecting the house with the outside current.



Show the part that melts when overheated.

Dangers from Electricity. Electricity, unlike fire, cannot be seen, and consequently we may be harmed by it. If the air were moist, a person might receive a fatal charge from a high tension wire by coming close to it, although he did not touch it, for the electricity can jump across the gap. The resistance to electricity through the body also differs greatly at different times. If your hands or feet are wet, or if you are bathed in perspiration, it is quite possible for the ordinary 110-volt current to cause serious injury or possible death. Sometimes the insulation inside a fixture is defective so that the fixture itself is connected to a "live" wire. If a person were in water, in a bath, or were to touch a water faucet with one hand and a defective lighting fixture with the other, the shock received might cause death. Death has been caused by people having an electric pad in bed along with a hot-water bag. If the hot-water bag breaks and allows water to flood the heating pad, it causes a short circuit and might kill the person. Be sure when working with electricity never

ESSAY TEST

Does Jason Offer Some Sound Advice?

Read carefully and critically. List all the errors and suggest corrections.

The human body will conduct an electric current, even though it is an insulator. A current that might pass harmlessly from one hand to the other through the chest might be serious if it passed just through one limb alone. If an electric shock stops the breathing, the person is dead and there is no help for him. If an electric lamp does not light, remove it and use a screwdriver to pry up the center connection in the socket. That sometimes is so flat it does not touch the base of the lamp. If the electric-iron cord burns off, you can tell whether the fuse is blown or not by joining the two bare ends of the wires in the cord with a piece of metal. If it makes a spark, the fuse is not blown.

THE REVIEW SUMMARY

In preparing a summary of what you have found out in this unit, you will want to place emphasis on the big ideas which have come from the applications of the facts you have learned and the demonstrations you have seen. Doubtless you have done some additional reading which has helped you put together some of the facts into generalizations or fundamental underlying principles. For this unit these generalizations are:

1. There is a close relationship between electricity and magnetism. An electric current always produces a magnetic field.
2. Electrical energy is transformed into mechanical energy through the agency of electromagnets.
3. Electrical energy is transformed into heat energy through the agency of resistant conductors.
4. The heating effect of the electric current is used to open circuits by means of a fuse.
5. The house current carries enough electrical energy to kill a person.

Before making your review summary for your workbook, test your knowledge of the facts of the unit by checking over the text so as to be sure you know the facts underlying the science principles

or generalizations. Then using this material and everything you have read, seen, or done yourself, make your summary outline. This outline you may use when you make a recitation.

TEST ON FUNDAMENTAL CONCEPTS

In a vertical column under the heading CORRECT *write the number of all statements you believe are true. In another column under* INCORRECT *write numbers of the false statements. Your grade = right answers* × $3\frac{1}{3}$.

I. **An electromagnet:** (1) gets its magnetism from a current of electricity; (2) may be made more powerful than a permanent magnet; (3) as a rule has a core of hard steel; (4) is used in electric irons and heater; (5) becomes a permanent magnet when the current is cut off.

II. **The electric bell has:** (6) a permanent magnet armature; (7) insulated soft iron cores; (8) coils of bare copper wire; (9) a device for automatically opening and closing the circuit; (10) a copper armature.

III. **The electric motor:** (11) has an electromagnet for an armature; (12) has an electromagnet for the field magnet; (13) has an electromagnet for its commutator; (14) works on the principle that like poles attract each other; (15) can only work by rapidly changing the poles either of the armature or of the field magnet.

IV. **Electrical energy is changed into:** (16) heat when a strong current passes through a resistant wire; (17) light in the electric iron; (18) heat and light in the electric light bulbs; (19) chemical energy when it melts a fuse wire; (20) heat when glass is rubbed with silk.

V. **Electric fuses:** (21) have a high melting point; (22) prevent many fires; (23) would not be useful if electricity did not heat conductors; (24) are made of different current-carrying capacities; (25) are not needed in modern wiring systems.

VI. **An electric current may cause damage or injury when:** (26) a fuse is blown out; (27) a piece of metal is put into a lamp outlet; (28) the insulation is worn from a portable lamp cord; (29) a bare wire inside a metal fixture makes contact with it; (30) a person turns on the water with one hand and an electric light with the other at the same time.

PRACTICAL PROBLEMS

1. Study the electric outlets in your house. Make diagrams of a few rooms to show lamps and outlets. Locate the fuse box, meter, and main switch; make a diagram of fuse box and circuits going

from it. Test circuits and list location of lights and outlets controlled by each pair of fuses. Keep this chart of location and fuses in a convenient place so that you will know just where to put in a new fuse if the lights fail you on any one circuit.

2. You go out after a severe storm. You see an electric light wire has been broken, and one end is dangling near the ground, while the other is resting on the ground. There are several small children playing near by. What will you do?

3. Your electric lights go out suddenly. You find the burnt fuse and see it is a 10-ampere fuse and put in another like it. Just as you screw it in it blows out. You put in a 15-ampere fuse. It blows out. The next fuse you have is a 40-ampere fuse. Should you put that in? If not, what is the proper thing to do?

INTERESTING THINGS TO DO, READ ABOUT, OR SEE

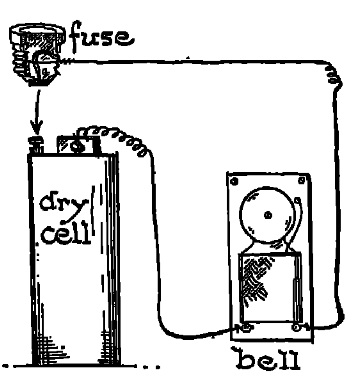
1. Find out all the uses you can that are made of electric bells and buzzers.

2. Read about Joseph Henry and his work in developing the electromagnet.

3. Trace the wiring of the doorbell circuit in your house. Show in a diagram the buttons, bell, source of current (battery or transformer or lighting circuit), and wires.

SCIENCE FOR LEISURE TIME

1. Make a collection of materials used for electric insulation. Carefully label each article, telling what specific use it has. Add these to your personal science museum.



2. Magnetize your knife blade, nail file, scissors, and screwdriver by means of an electromagnet that you have made.

3. How to tell if a fuse is good. Sometimes it is difficult to see whether the fuse wire is melted or not. By connecting a dry cell, a bell, and the fuse in circuit you can easily tell. Wind the bare wire from one binding post of the bell around the metal of the fuse. Close the circuit by pressing the center contact of the fuse to the free pole of the dry cell. If the bell rings, the fuse is good.

4. Learn how to replace a blown fuse. Do not attempt this without first securing expert advice.

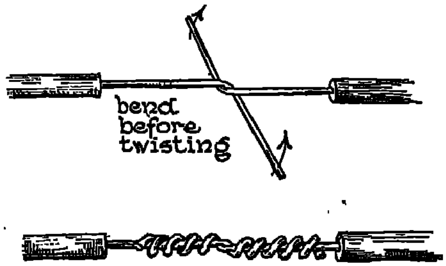
SCIENCE CLUB ACTIVITIES

1. The Electric Motor *vs.* All Other Devices Operated by Electromagnets

Divide the club into two groups to decide which is of the greatest benefit to mankind — the electric motor or all the other devices operated by electromagnets. Each group will collect all the facts possible and at an announced future meeting have a regular debate with judges invited from outside the club to come in and give a decision on the merits of the debate.

2. Splicing an Electric Cord or Wire

This is a good practical exercise for each member to learn to do. The best way to learn is actually to splice two ends of wire together. Cut the insulation off for a distance of 1½″ to 2″ from the end. Scrape the wire until it is clean and shiny. Bring the two wires together as shown in the diagram and twist each end around the other wire. After these are twisted tightly together, cover well with liquid solder and allow to dry over night. Then bind with three layers of electrician's tape, having the strips overlap well and covering at least an inch of the insulation on the wire. If you can get someone who knows how to do hot soldering, the wire may be soldered the regular way instead of with the cold liquid solder.



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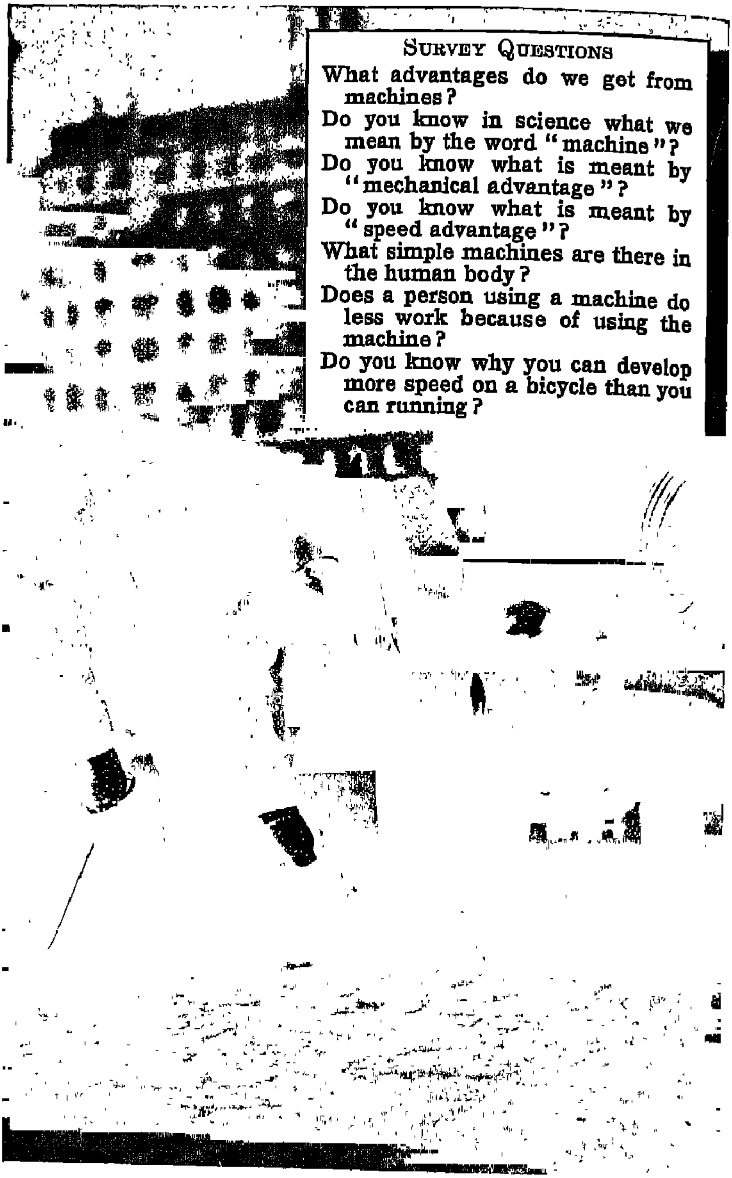


SURVEY QUESTIONS

What advantages do we get from machines?

Do you know in science what we mean by the word "machine"?

Do you know what is meant by "mechanical advantage"?

Do you know what is meant by "speed advantage"?

What simple machines are there in the human body?

Does a person using a machine do less work because of using the machine?

Do you know why you can develop more speed on a bicycle than you can running?

Keystone View Co.

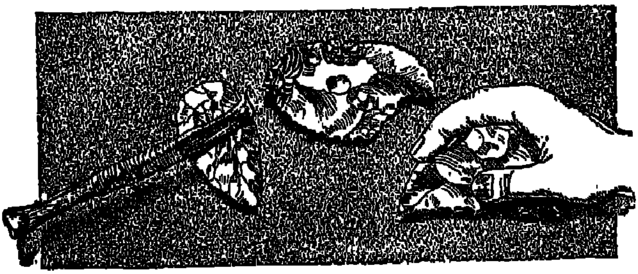
UNIT VIII

SIMPLE MACHINES IN THE HOME

PREVIEW

In primitive times man did not use machines. If he could not do the necessary work with his body he had no other way of getting it done. Perhaps by chance he discovered that if he stuck a big stick under a rock, he could move the rock, and this gave him the idea of the lever. Archimedes, a Greek who lived before Christ, had such a respect for the power of the lever that he once said, "If I had a place to stand, I could move the world." Just what he meant we shall see later.

Early man contented himself with a few very simple implements. He had pestles and mortars for grinding acorns, corn, and other grains. He had rude stone axes; he made bows and arrows, thus using laws of machines in their use. He even had bone needles and other imple-



Are these tools machines? Read your text carefully before you answer.

ments to help him make such simple clothing as he wore. These simple tools were in reality machines, although man did not know this because he did not understand

the principle of machines. It has been in comparatively recent times that man has come to make extensive use of machines. With the discovery of the law of gravity and the knowledge that we have to overcome this force as well as that of friction and inertia, science began to make real progress in making machines that would save labor.

What machine is this the forerunner of?

If we had lived a great many years ago, we would have found that there were very few devices which enabled our ancestors to save labor in their homes. Much work was done by hand, and a few simple machines, such as churns, spinning wheels, wagons, and the like, were used to do most of the mechanical work. In the present era, an age of machinery, we have come to save time and also save our own energy by using machines to help us do the work. We find also that machines are usually much more efficient than we are, and so it is that we have year by year an increasing number of devices for labor saving in our homes. It is a wise housekeeper who can select from such a multitude of machines now offered in the market those which are mechanically perfect, as well as serviceable and durable. It is the purpose of this unit to point out a few of these machines, and to try to explain the simple principles which underlie their construction and regulation.

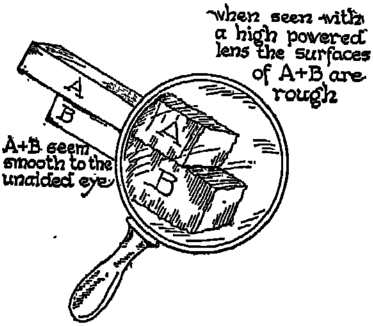
PROBLEM I. WHY DO WE USE MACHINES?

Gravity. We have always known that apples fall and that a ball thrown into the air will return to the earth, and we do not wonder about it. Yet why is it that apples loosened from the tree do not rise? Why do not all

unattached bodies rise? It would be no more wonderful for bodies to be repelled from the earth than it is for them to be attracted to it. But just why the earth attracts rather than repels objects is one of the mysteries of the universe. The fact that bodies fall, not only aroused the curiosity of Sir Isaac Newton, but started a train of thought and reasoning which took him years to think through. Eventually, however, Newton gave to the world the *Law of Gravitation*. This law not only helps explain how the heavenly bodies maintain their courses in the heaven, but also the behavior of falling bodies. He believed that every particle of matter in the universe attracts every other particle, and he called the attraction of the earth for bodies on or near its surface *gravity*. We know that the lightest as well as the heaviest kinds of bodies are eventually pulled down to the earth, as a speck of dust, a feather, or a lead sinker. But how many think of the weight of an object as a measure of the force of gravity acting on it? We have read perhaps that the force of gravity depends on the amount of matter in a body. For example, on the planet Mars, where the amount of matter is about ½ that of the earth, a man weighing 150 pounds on earth would weigh only about 75 pounds. Consequently he could jump further and higher than on the earth, provided his muscles would do the same amount of work.

Weight. What do you mean when you say that you weigh 110 pounds? Simply that the mutual attraction between you and the earth is 110 pounds. Weight is, therefore, the *measure of gravity*. The units of weight are arbitrarily determined. In our English system the ounce and the pound are units of weight. In the metric system, used in scientific work, the gram and kilogram are units of weight. These weights are legalized by the government and standard weights are kept for comparison.

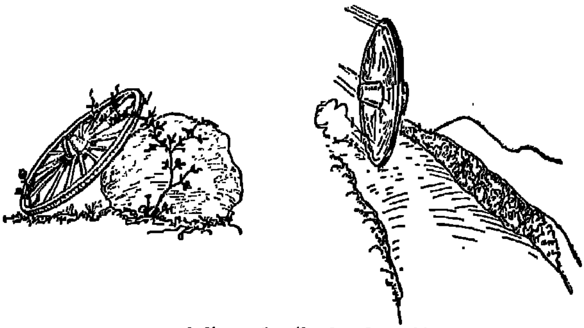
Friction. If you are drawing a loaded sled over the snow-covered sidewalk and suddenly come upon a place covered with ashes, you find it necessary to use much more force. This increased resistance comes from greater friction. In all machines, and in all movement of one body over another, there is friction. If the wind is driving a sailboat through the water and the wind suddenly stops, the boat will continue to move for some distance, but eventually it stops. What stops it? A boy slides down a toboggan chute and at its base comes out upon the level ice of a lake. After leaving the incline of the chute, he goes slower and slower until finally he stops. What stops him? It is friction. Friction is the resistance caused when one body moves against another.



Explain the causes of friction.

The Causes of Friction. When one body is moved over another, the elevations on one sink into the depressions of the other. They must be separated a little to move the elevations of one over the elevations of the other. These alternate movements require a certain amount of work. In doing this work, we are overcoming the resistance we call friction. If the surfaces of two objects moving are very rough, the friction between them is great. When the surfaces are smooth, there will be little friction. Friction produces heat. It causes matches to light, pencil points to wear away and become dull, belts to grip the wheels of machinery, and brake linings to wear out. It helps a car move, and it also wears out the rubber tires on that same car.

Inertia. Among the laws stated by Newton we find this: Bodies at rest remain at rest unless some outside force acts to move them. Bodies in motion continue to move in a straight line unless some external force acts to



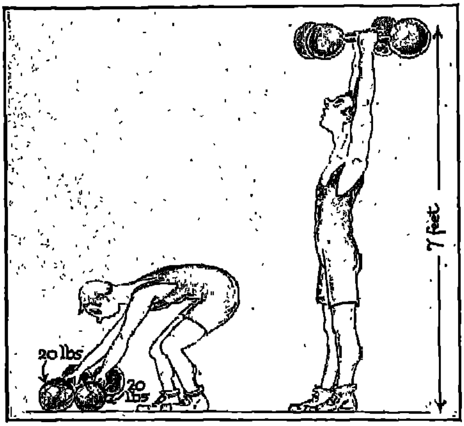
Read your text carefully and tell what law this cut illustrates.

stop or change the direction of the motion. This tendency of a body at rest to remain at rest is called *inertia of rest;* the tendency of a body in motion to continue in motion is *inertia of motion.* For example, a ball at rest will not move unless some outside force (person or thing) makes it move, and, if in motion, it will continue to move until some force stops it. Since force is required to start or stop a body or, in other words, to overcome its inertia, inertia is *a resistance to force.*

Work. There are then three types of resistance: gravity, inertia, and friction. In overcoming any one of these, work is done. This work is generally reckoned in terms of opposition to gravity. A pound lifted one foot is one foot-pound of work. If the same amount of work is done against friction or in overcoming inertia, it is also one foot-pound of work. When we lift a weight, we do work, and when a weight falls, it is also capable of doing work.

Why Use Machines? It often happens that the resistance to overcome is greater than the force that is avail-

able. For example, a man can lift 200 pounds, but he wishes to lift a safe weighing 1000 pounds. It is possible to devise some sort of machine by which he can use the 200 pounds through five times as great a distance and to move the 1000 pounds.



How much work is this boy doing?

The Law of Machines. Most people think that by using machines they avoid work. But this is not true, for although household devices employed as machines do work and make it easier, we still do work. Machines do not *make* energy. They simply transfer or exchange force or mechanical energy from one place to another. We shall see as we go on in our study of science that energy is simply the ability to do work. Sometimes this energy is locked up, as in coal, which gives heat when burned, or it may be evident as in the power in the running stream, or in the waves, or in the wind. By use of a machine we may transfer this energy or power from one place to another, and by means of a machine get work done more effectively. The chief value of simple machines lies in their enabling us to overcome a large resistant force by applying a small force. But we must remember that we can get no more work out of a machine than we put into it. The law of machines may be stated as follows: *The force applied to a machine times the distance through which it acts equals the resistance overcome times the distance through which it is overcome.* That

is, if you move a 200-pound weight one foot by applying a force of 20 pounds, this force of 20 pounds must act through a space of 10 feet. $200 \times 1 = 20 \times 10$.

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange the words in proper numerical order. A word may be used more than once.

bring	speed	inertia	push
rest	work	energy	25
motion	30	resistance	force
11	push	rubbing	attraction
weight	moving	overcome	pull
put	gravity	friction	machines

Force is a (1)____ or a (2)____. When a (3)____ acting upon a body overcomes its (4)____ and moves it through space, (5)____ is done. Three types of (6)____ which a force may overcome in doing (7)____ are: (8)____, (9)____, and (10)____. When 5 pounds of lead are lifted vertically 6 feet, (11)____ foot-pounds of (12)____ are done. We can get no (13)____ out of a machine that is not (14)____ into it. (1 and 2; 8, 9, and 10 interchangeable.)

ESSAY TEST

Shirley Grumbles over Her Study of Machines

Read carefully and critically. List all the errors and suggest corrections.

Why a girl should study about machines I can't tell. Just think of all these new terms. How can anyone be expected to remember them. Let me think them over.

1. A push is a force that pulls.
2. Gravity is a measure of work.
3. Friction is misunderstanding or dispute.
4. Inertia is a girl's name.
5. Work is the overcoming of resistance through space.
6. A foot-pound is that unit which measures the work done in pushing a pound along for one foot.
7. This is a law of machines: Machines create energy.
8. Machines make our work easier.
9. Bodies in motion can never stop.
10. The earth is a body in motion.

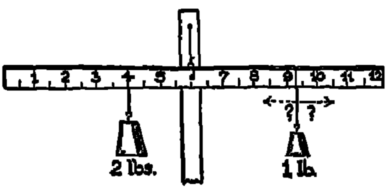
PROBLEM II. HOW DO SIMPLE MACHINES MAKE WORK EASIER?

Machines Used in the Home. If you examine the various devices used in the home, you will be surprised to learn how many different kinds of machines there are. What do you find in the kitchen? A water faucet, a knife, a knife sharpener, a can opener, a bread mixer, an egg beater, a cake mixer, and an ice-cream freezer. In the tool box what do you find? A screwdriver, drill, chisel, saw, hammer, and wrench. These are a few examples of the many machines in use in the home. All machines, even such complicated ones as the sewing machines, the typewriter, and the automobile, are made up by combining simple machines. There are only six simple machines from which the most complex machines are built. These six simple machines involve only two distinct machine principles which underlie two typical machines, the lever and the inclined plane. The crowbar and the wheelbarrow are common lever machines. A road upgrade, the blade of a carpenter's plane, and the skid of the truckman are examples of the inclined plane.

The Lever. When you used the seesaw, you probably discovered that if a lighter boy or girl were at the other end, you had to move nearer to the middle. The principle of the lever will explain the reason for this.

Demonstration 1. Principle of the Lever.

A ruler suspended at its middle point is a lever. This support about which turning takes place is called the *fulcrum*. The load we hang on one side is the *resistance* and the force we use on the other side of the fulcrum to balance the load is the *effort*.



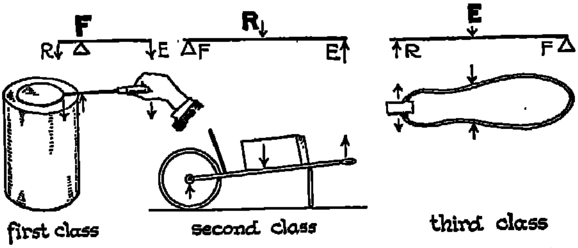
With the lever illustrated, find out where an effort of 1 pound must be applied on

the effort arm to balance the different weights (resistances) suggested in (*a*), (*b*), and (*c*), applied on the resistance arm. (*a*) Place 2 pounds 2 inches from the fulcrum. (*b*) Place 2 pounds 4 inches from the fulcrum. (*c*) Place 6 pounds 1 inch from the fulcrum.

Can you work out the principle of levers by comparing the forces and lengths of arms in each case? What statement will you suggest for the law of levers?

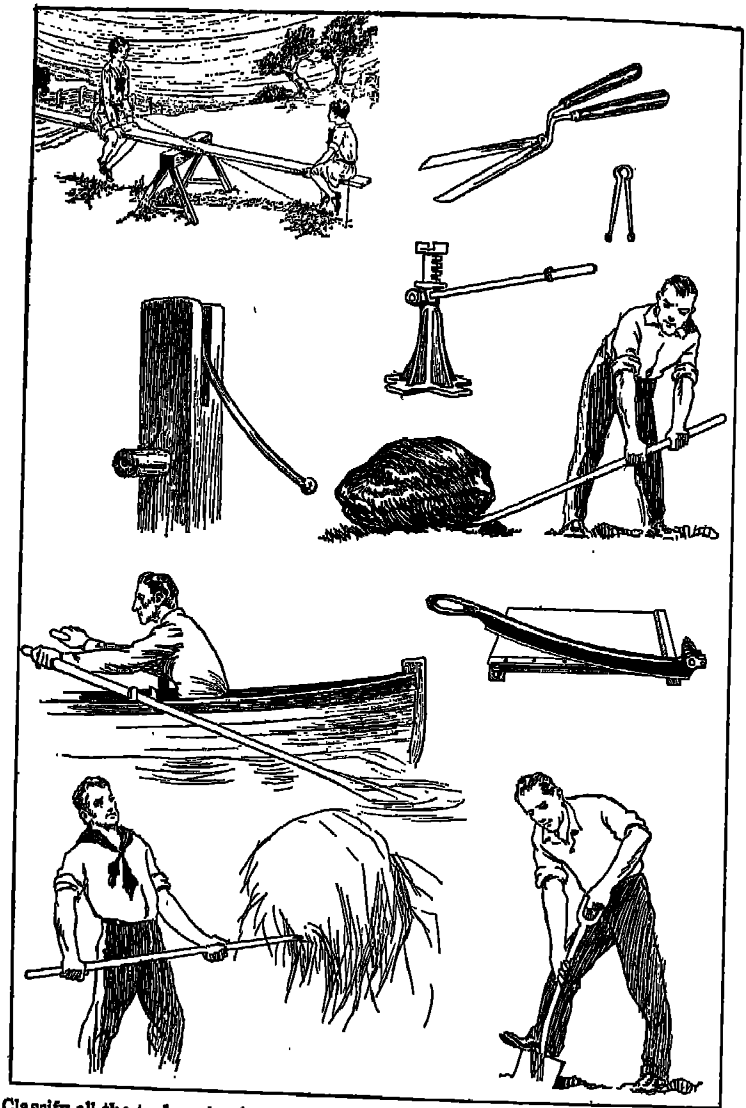
The distance from the resistance to the fulcrum is the resistance arm; the distance from the effort to the fulcrum is the effort arm. Experiments prove that effort (E) times effort arm (Ed) = resistance (R) times resistance arm (Rd). $E \times Ed = R \times Rd$ (d is the distance in each case). When you use a pair of scissors, the force you use is greater if the cloth you use is 3 inches from the fulcrum than when it is $\frac{1}{2}$ inch from the fulcrum. Can you explain why?

Three Classes of Levers. There are three classes of levers which depend on the position of the fulcrum, the resistance, and the effort. The relative positions of these are as follows: In levers of the first class, the



Can you explain three classes of levers from this diagram?

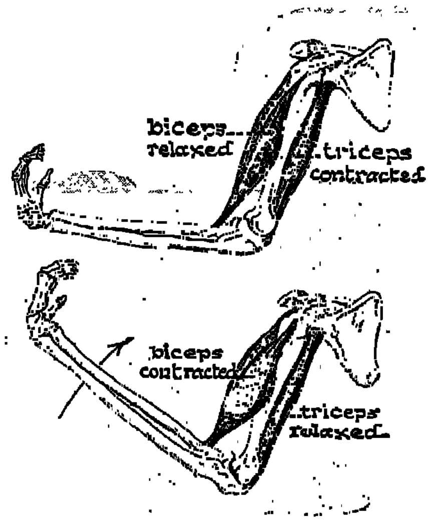
fulcrum comes between the resistance and the effort; in levers of the second class, the *resistance* comes between the fulcrum and the effort; in levers of the third class, the *effort* comes between the resistance and the fulcrum. An easy way to distinguish the classes of levers is to remember which of the three factors is in the



Classify all the tools or implements shown on this page as levers, giving the class, the fulcrum, the resistance, and the effort in each case. Make up a table for your workbook.

middle. They are in the order *F*, *R*, *E*, as will be seen in the diagram.

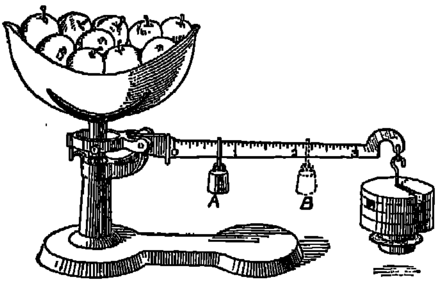
Advantages of Machines. Machines are used for two reasons. They may give mechanical advantage or they may give speed and distance advantage. We use a machine to overcome a force greater than that which is applied. If by means of a machine we can lift 200 pounds by applying an effort of 25 pounds, then the *mechanical advantage* of the machine is 8; it is equivalent to the resistance divided by the effort. With levers of the third class we must apply an effort greater than the resistance to be overcome. Then why use such a machine? It is because it gives a *speed* or *distance advantage*. The advantage of levers of the third class is shown by the human arm. Notice how small the movement of the muscle is when you bend your arm at the elbow and how great the space is through which your hand moves.



When, by contracting, the biceps shortens slightly, the hand is raised about twelve inches. ***Locate resistance, effort, and fulcrum in the diagrams.***

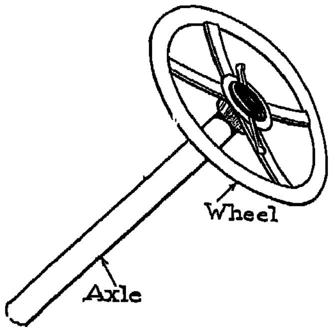
How We Weigh Things. A pair of scales in the home is a present-day necessity. It may save its cost many times over in the checking of the weight of groceries and other materials. Of more importance to some people is the checking of their own weight each week to see that they are keeping in the best of condition for good health.

In the scales in the picture, can you tell whether you would get more or fewer apples if the sliding weight were moved from the point *A* to *B*? Can you explain why? Most of the household scales are not dependent on the principle of the lever but upon the stretching of a spring. To explain such a scale, let us suspend a coiled wire such as comes out of a window-shade roller. Fasten a pointer to the spring at the bottom. Let us now hang weights of 10, 20, and 30 grams respectively to the lower end of the spring. As each weight pulls the wire down, mark the position of the pointer on the scale to mark where each weight holds it. As long as the elasticity remains in the wire, we can use this spring for weighing purposes. This is the principle of the spring balance or postal balance used for weighing letters.



Apply the principle of the lever as used in weighing. Where is the fulcrum, the resistance, and the effort?

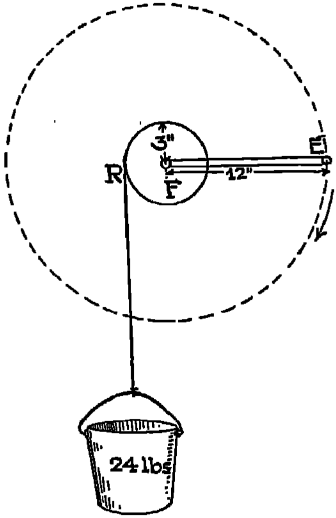
The Wheel and Axle. The steering wheel in the automobile, just like the crank of a windlass for drawing water, is a machine using the lever principle, as can readily be seen by studying the diagrams.



Where are effort, fulcrum, and resistance here?

The radius of the axle corresponds to the resistance arm, and the length of the crank or radius of the circle

which the effort describes corresponds to the effort arm. If the crank is 12 inches and the radius of the axle is 3 inches, what force will be required to raise a pail of water weighing 24 pounds?



Using your text, explain this diagram.

$$\text{Effort} \times 12 = 24 \times 3.$$

$$\text{Effort} = \frac{24 \times 3}{12} = 6.$$

It will take 6 pounds to raise the water.

The ice-cream freezer, the bread mixer, the knife grinder, the egg beater, the drill and bit stock, and the bicycle are but a few of the machines you can readily find which are of the wheel-and-axle type.

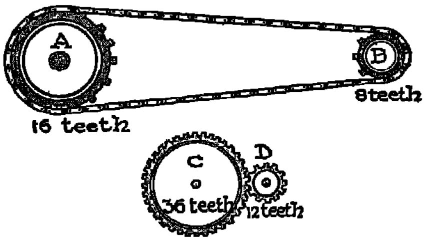
Demonstration 2. To Illustrate Changing Speed by Use of Wheels of Different Diameters Joined by Belt or Gears.

Materials. A Dover egg beater or drill with gear and wheels. Bicycle.

Method. (*a*) Mark one point on the working part of the egg beater. Observe how many times this revolves for one complete turn of the handle. Try this three times. (*b*) Count the number of cogs on the two wheels which connect the force end of the machine to the work end. What is the relation of the number of cogs? (*c*) Make similar comparison of the cogs on the rear axle and on the sprocket wheel of your bicycle. Find the number of revolutions of the rear wheel to one revolution of the crank. What general rule regarding change of speed is suggested to you by these observations?

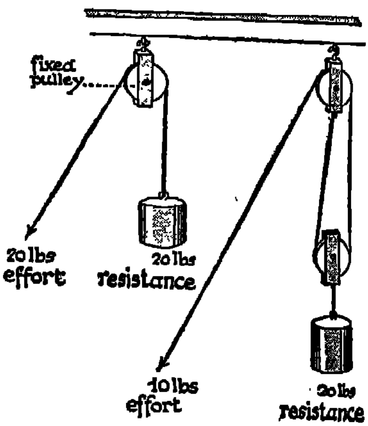
The bicycle makes use of the wheel and axle, not for mechanical advantage but for

speed advantage. The pedal cranks turn the sprocket wheel which is joined by chain to a gear on the rear or drive wheel. The circle through which the pedal moves is smaller than the circle through which the rim of the wheel moves. The gears are of such ratio that the rear wheel turns faster than the sprocket wheel. The resistance is applied where the rim of the wheel pushes on the road beneath it. Consequently, the resistance is acting through a much greater distance than the effort. The racing bicycle, by use of a larger sprocket wheel, is geared for even greater speed advantage than the ordinary machine.



Geared wheels make possible changes in speed. If *B* is attached to the rear wheel of a bicycle and *A* is the sprocket wheel turned by the pedal crank, one complete circle completed by the foot will produce how many revolutions of the rear wheel? Would you increase or decrease the number of cogs in *A* to make the bicycle easier to run? to increase the speed? Tell the story of *C* and *D*.

Pulleys. Have you ever noticed when you open a window how easily you can lift the window? It is because back inside the casing there are heavy window weights pulling down on a cord which is looped over a pulley and fastened to the window frame. The wheel in the pulley turns but the pulley always remains in the same place and so is called a *fixed* pulley. Fixed



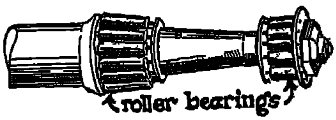
When would you use the fixed pulley? The movable pulley?

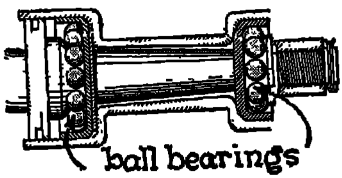
pulleys are used to change the direction of a force, to raise objects to high elevations, and in the block and tackle. There is a pulley at the top of a tall flag pole.

If you have one end of a rope fastened to a post on the pier passing over a pulley at the bow of your boat and the other end in your hands, you can pull the boat in quite easily. The pulley moves with the boat and is called a *movable* pulley. Used as suggested, it has a mechanical advantage of 2. That is, if the boat resistance is 100 pounds, you use only 50 pounds to pull it in. The reason for this can be seen by applying the lever principle to it.

A combination of fixed and movable pulleys is found in the block and tackle. This is used for raising very heavy weights and overcoming large resistances. If we neglect friction of the moving parts of the machine, a given force (effort) can overcome a resistance as many times as great as itself as there are cords coming from the movable block. By means of the block and tackle a single man can easily lift a heavy piano.

Wheels and Runners. Why do our wagons have wheels and our sleds runners? Have you ever pulled with all your might to drag a heavily loaded box over the floor and then placed one or more rollers under it and found how easily it could be pulled? In much the same way a load on a wagon is moved over the bare road more easily than the same load on a sled. The sled runner slides over the road surface, while the wagon wheel rolls over it; and *sliding friction* is greater than *rolling friction*.





Name several machines and tools which use roller or ball bearings. Why are roller bearings useful?

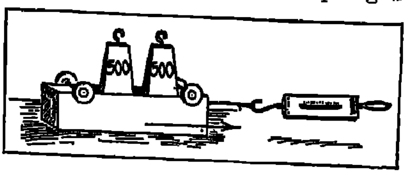
But why not use wheels on ice and snow? If you ever tried your roller skates on ice, you know the difficulty of getting started. This is because of the lack of sufficient friction. Such smooth surfaces as glass, ice, and well-worn snow have very little resistance to the movement of hard objects over their surfaces. Sled runners have many more points of contact with a supporting surface than have wheels; but because of the very low friction between ice and smooth steel, steel runners are better for snow and ice than wheels. With skates there are fewer points of contact and the friction is sometimes reduced still more for another reason. When skating in moderate weather, the pressure, due to your weight, melts the ice under the runners and you really glide over water. This water freezes instantly after the skates have left it.

Demonstration 3. To Compare Work of Moving a Body against Gravity and against Friction.

Materials. Metal car with low-friction wheels, spring balance, weights, string, and meter stick.

Method and Results. *A*. Load car with weights until car and weights register between 1000 and 2000 gm. Lift this to a vertical height of 20 cm. Record the weight. How much work was done in lifting it 20 cm. high? Give work in gram-centimeter units.

B. Lay the car on the table with wheels in the air. Place weights on the car. With spring balance attached to car by a string, pull horizontally and as steadily as possible. Read the balance at the start and again when the car is moving steadily. What force was required to start motion? What force was required to keep up a uniform motion after starting? How much work was done against friction in drawing the load 20 cm.?



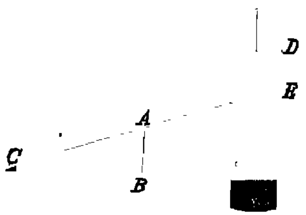
C. Now turn the car over so that it rests upon its wheels. Load it as before. Draw it over the table and read the balance at the start and again when the load is being moved at uniform speed.

Can you explain from this picture how the inclined plane was used in building the pyramids? These great structures, built far from the source of the stone used in their construction, are still rated as one of the wonders of the world. We cannot account for the raising of these huge blocks of stone to their places in the structure unless we say that the Egyptian engineers had a knowledge of the use of the inclined plane. This is the artist's conception of how it was used.

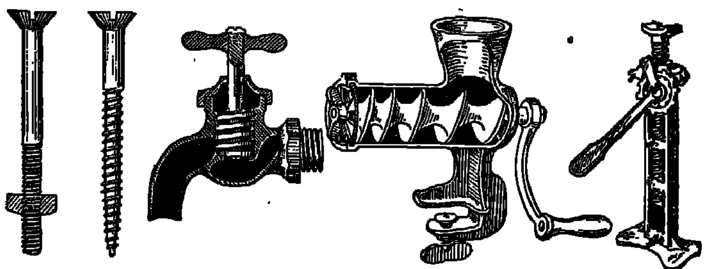
What force was required to start it? What force was required to keep up uniform motion after starting? How much work was done against friction in moving the load 20 cm.?

Conclusion and Explanation. Why is the work done in moving the weight 20 cm. different in all three cases? What conclusion do you reach regarding the use of wheels? Why was the force required to start the load different from that required to keep it moving after starting?

Inclined-Plane Machines. The huge Egyptian pyramids were built long before the invention of modern machines, and it has long been a mystery how these massive blocks of stone were raised into place. The most plausible explanation is that they built long inclined roadways up which they dragged them. Our roadways up hills are inclined planes. It can easily be shown by experiment with a spring balance that it takes much less force to draw a given load up an inclined surface than to lift it vertically against gravity.



Observe how the screw is in reality a spirally inclined plane. Explain diagram.



Illustrating the use of the screw. How many other machines can you mention that use this principle?

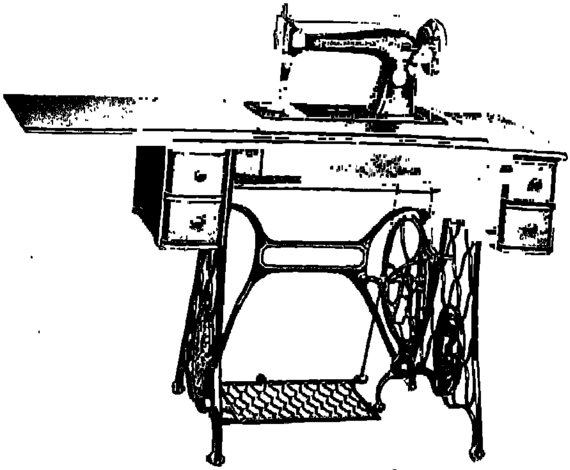
If you examine the cutting end of a chisel or a carpenter's plane, you will notice that it is flat on one side and

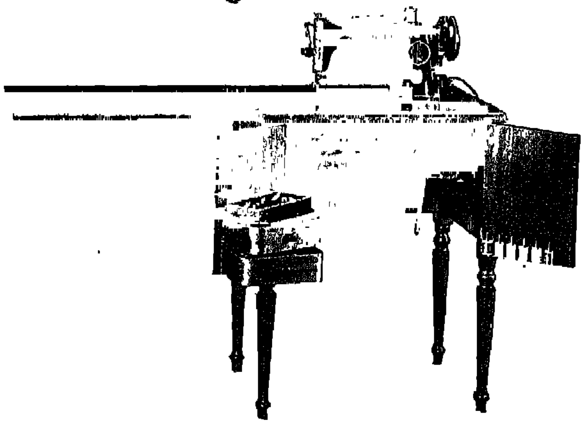
the other side is an inclined surface. An ax is a double incline; that is, both surfaces are inclined. This is also true of a knife blade, pins, needles, and a wedge. This special form of the inclined plane is called the wedge. When an inclined surface turns in a spiral, we have a machine called the screw. Ordinary screws are machines, as are the powerful jack screws used to lift automobiles and buildings.

The Sewing Machine. A great many other types of machines can be found in our homes, but one almost always present is the sewing machine. Since 1850 these machines have been improved more and more, so that now their work is extremely rapid and efficient. In early times the power was transferred by a treadle to the drive wheel. If we measured the diameter of this wheel and the diameter of the pulley over which the belt passes, we could easily determine how many revolutions of the pulley would be produced by one revolution of the drive wheel. Then by carefully turning the pulley one complete revolution, we could find how many stitches the machine took in each complete revolution. Today most sewing machines are run by electricity.

Machine Stitches. There are two kinds of stitches made by machines. Both of them differ from the hand-made stitches. The chain stitch is so made that if the thread is broken at the right place and the free end is pulled, the thread can all be pulled out. You find this stitch on the bags of sugar obtained from your grocer. The common machine stitch is the lock stitch. Two threads are required for this: a lower one fed from a bobbin and the upper from a spool. A device for regulating the tension on the thread is very important because if the tension is not carefully adjusted the threads will not be locked in the middle of the cloth. If one thread is either on top or at the bottom it can be pulled out easily.

But when both threads are linked together inside, a durable seam is made which will not rip easily.





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The upper picture shows the old-fashioned type of machine which was run by foot power. The lower picture is a modern electric machine. Which would you rather use? Why?

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

one	more	wheel and axle	distance
two	same	block and tackle	effort
three	less	inclined plane	machines
four	gravity	labor saving	lever
five	push	simple machine	resistance
six	effort	ability to work	work

When we use simple (1)____, we must do just as much (2)____ as if we did not use them, but the effort we apply may be very much (3)____ with the (4)____ than without them. If we wish to lift 500 pounds by applying a force of 125 pounds, the ratio of the arms of a lever would be effort arm (5)____ to resistance arm (6)____. We could accomplish the same thing by using a pulley whose movable block was supported by (7)____ ropes. Classified as simple machines: the hammer is a (8)____; the windlass is a (9)____; and a road uphill is an (10)____. A general law of simple machines is this: (11)____ × (12)____ equal (13)____ × (14)____. If the small sprocket on the rear wheel of a bicycle has nine gear teeth, and the large sprocket wheel has twenty-seven gear teeth, the rear bicycle wheel will make (15)____ revolutions to each single revolution of the foot on the pedal.

ESSAY TEST

Gleason Recommends the Use of Machines

Read carefully and critically. List all the errors and suggest corrections.

If you think machines are of no value because you must do more actual work with the machine than the useful work accomplished, just try to use a bit for boring holes in wood. What can you do with your bare hands? Just nothing, but by using a bit brace, which is a type of wheel and axle, you can easily bore the hole. By using the wheelbarrow, another wheel-and-axle machine, I can lift 300 pounds easily. First-class levers give more mechanical advantage than any other lever of the same length; that is probably why it is called "first class." The spring balance for weighing is classed as a pulley, because things you weigh pull down on the spring. It seems silly to call a road uphill a machine, but it is because it requires less effort to get up a hill that way than to go straight up. When I am in a hurry to get any place, I use my bicycle; that is a machine that has lots of speed advantage.

REVIEW SUMMARY

In preparing a summary of what you have found out in this unit, you will want to place emphasis on the big ideas which have come from the applications of the facts you have learned and the demonstrations you have seen. Doubtless you have done some additional reading which has helped you put together some of the facts into generalizations or fundamental underlying principles. For this unit some of these generalizations are the following. Can you add others?

1. Force is required to move matter, and when it does this, work is accomplished.
2. Gravity is a natural force always acting.
3. Through the use of machines work may be done that would otherwise be impossible.
4. No machine can deliver quite as much work as is put into it.
5. No two bodies can be rubbed together without a change of some of the mechanical energy into heat energy.

Before making your review summary for your workbook, test your knowledge of the facts of the unit by checking over the text so as to be sure you know the facts underlying the science principles or generalizations. Then using this material and everything you have read, seen, or done yourself, make your summary outline. This outline you may use when you make a recitation.

TEST ON FUNDAMENTAL CONCEPTS

In a vertical column under the heading CORRECT *write numbers of all statements you believe are true. In another column under* INCORRECT *write numbers of the false statements. Your grade = right answers* $\times 3\frac{1}{3}$.

I. **Force is:** (1) the weight of a body; (2) the resistance of a body to motion; (3) a push or a pull; (4) the result of doing work; (5) the same as work.

II. **Work is:** (6) done whenever force is exerted upon a body; (7) the overcoming of resistance through space; (8) the amount of force used; (9) the amount of resistance overcome; (10) anything that is hard to do.

III. **In all simple machines the:** (11) effort equals the resistance; (12) product of effort by the distance through which it acts is equal to the product of the resistance by the distance through which it is overcome; (13) effort times the resistance equals the work done; (14) work done on the machine equals the work done

by the machine (neglect friction); (15) advantage is always mechanical.

IV. **When by use of a lever a force of 4 pounds moves 10 feet in raising a weight 2 feet:** (16) the weight (resistance) is 8 pounds; (17) the weight is 5 pounds; (18) the weight is 20 pounds; (19) the force arm is twice the length of the resistance arm; (20) the resistance arm is $\frac{1}{5}$ the length of the effort arm.

V. **There are 4 ropes supporting the movable block of a block and tackle. If a force (effort) of 20 pounds is used (neglect friction):** (21) the force will support a weight of 80 pounds; (22) the force will support a weight of 5 pounds; (23) when the force moves 20 feet, the weight moves 5 feet; (24) the movable block has two sheaves (wheels) in it; (25) the force of 20 pounds moves four times as fast as the weight.

VI. **A balance for weighing things may:** (26) be an equal-armed lever; (27) be an unequal-armed lever; (28) utilize the elasticity of a coiled spring; (29) be any one of the simple machines; (30) have a lower efficiency than most machines.

PRACTICAL PROBLEMS

1. What simple machine would you use to get water from a very deep well?

2. How would you calculate the mechanical advantage of a wheelbarrow? of a nutcracker? of the egg beater? of the bicycle-driving mechanism?

3. Plan how you would combine a wheel and axle, a pulley, and an inclined plane, so that a man using a 150-pound force can overcome a resistance of 60,000 pounds. Make a diagram and show how you work out the mechanical advantage of each machine. (Neglect the element of friction in the machines themselves.)

4. Make a list of the different ways in which friction has been useful to you within the last twenty-four hours.

INTERESTING THINGS TO DO, READ ABOUT, OR SEE

1. Read about the machines Archimedes made and used.

2. Visit a tailor shop to inspect the tailor's shears. Visit a tin shop to inspect the tinner's shears. Can you think of a reason for the difference you find?

3. Observe the different types of weighing machines you can find in the drug store, the grocery, the parcel post window, the express office, your kitchen or bathroom, the school laboratory, on the ice cart, and at the coal yard.

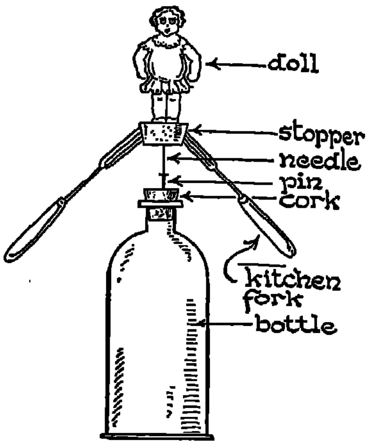
4. Find out how weight varies over the earth, above and below the earth's surface.

5. Observe some large machine as a steam shovel, a harvesting machine, or a locomotive. Try to identify several simple machines in it.

SCIENCE FOR LEISURE TIME

1. MAKE A DOLL BALANCE ON THE HEAD OF A PIN.

Push a pin half its length down into a cork which closes a narrow neck bottle. Push a needle vertically through the center of a large cork stopper. Have the point of the needle come about half an inch through the cork. Glue the feet of a large celluloid doll to the top of the stopper. Push the prongs of two kitchen forks into opposite sides of the cork stopper, having the handles come down at about a 45° angle, as shown in the diagram. Carefully place the point of the needle on the head of the pin. If well balanced you can spin the forks and the doll around rapidly without danger of their falling off. See if you can explain why this is.



2. Make a survey of all the machines used in your home, including those belonging to the house construction. Classify them according to types of machines.

3. Keep the machines of the home in good working condition.

4. Calculate the speed advantage of your bicycle.

5. Collect and mount pictures of common devices in which you can see one or more simple machines. Try to get all six of the simple machines.

SCIENCE CLUB ACTIVITIES

1. MAKE A BALANCE

By using the principle of the lever or action of a coiled spring deviso a balance using one of these. It may be for weighing letters having a scale in ounces or for weighing groceries having a scale marked in pounds. Meccano outfits can be used in making a balance. Weights may be cast from molten lead. A round mailing

tube cut to the right length and stoppered at one end will hold the molten lead in casting the weights.

2. A Block and Tackle

Get someone to bring to club meeting a practical block and tackle, or meet where you can see one in operation; count the ropes and the wheels and see if all the ropes move at the same speed. Measure distances. Effort and resistance move. Use a heavy-duty spring balance to measure effort. Compare resistance and effort and calculate the efficiency.

3. Try to get some official from the city or the state Bureau of Weights and Measures to talk to your club or your school on "Fraudulent Weights and Measures."

4. Arrange a debate on the question: If all friction were only one half as great as it is now, the world would be greatly benefited.

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Survey Questions

Do we use much of the sun's radiant energy? How do you know?

Do you know the cause of day and night?

Why are our days of different lengths?

What are the causes of our summers and our winters?

Are any of the sun's radiations beneficial? Harmful?

How did man keep time thousands of years ago?

What science principles are used in modern timepieces?

What is the difference between solar time and sidereal time?

What is the reason for having a so-called "daylight saving time"?

De Cou, Ewing Galloway

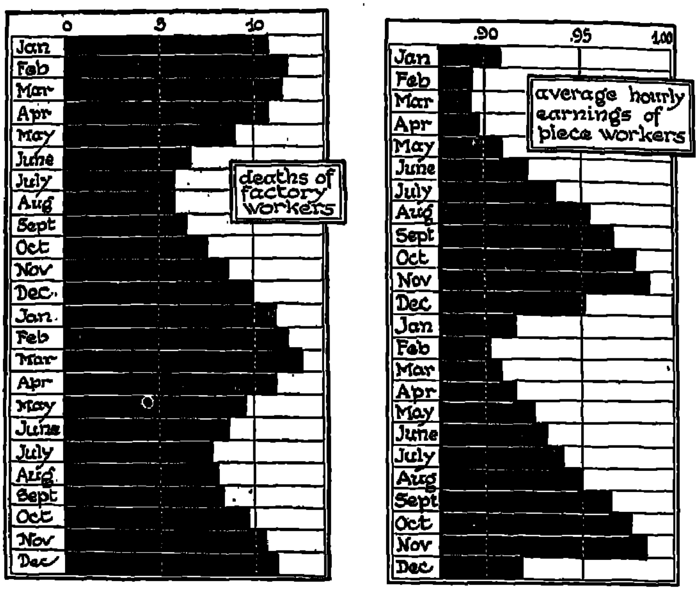
UNIT IX

THE SUN, TIME, AND THE SEASONS

PREVIEW

We think of the sun as the source of our light and our heat, and in fact all the energy which the earth uses. Every day, every year for millions of years the sun has been giving heat and light to the earth. Even the wood, the gas, and the coal which we use possess energy which originally came from this flaming ball of gas. Our day and night, change of seasons, weather, all the activities on the earth, we can trace back to the energy of the sun. We remember from our study of geography that the earth revolves around the sun once in $365\frac{1}{4}$ days, and that it also rotates once in 24 hours on its own axis. We also remember that the earth's axis is tipped so that it is inclined to the plane of its orbit. As a result of this tipping, we shall find that instead of a generally equal condition of day and night, we have some parts of the year when days are longer, and some parts of the year when they are shorter, or changing seasons. We have a variation in the amount of daylight and also a variation of the angle at which the sun's rays strike the earth. All these factors give us differences in temperature and have an important bearing on agriculture and many other industries. Many of our activities are determined by the period of daylight and by the season of the year. Much of our water power is seasonal, being greatest after the spring rains and the melting snows, and least after the heat of the summer. Prevailing winds and water cur-

rents in some parts of the world are dependent upon seasons. As a rule there is less sickness in the fall in this country than in any other time. With the coming of the cold season, sickness and the death rate usually increase. This increase continues until March, then things get better until June, which is almost as good as October for

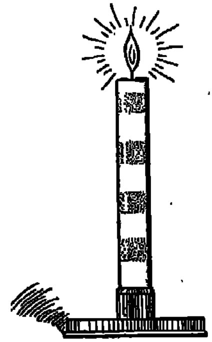


Read your preview carefully and then try to explain what you find in these graphs. What is the most favorable time for work? For health of factory workers. How would you account for this?

good health, while in the warm summer months the death rate is at its lowest. The changing seasons also have compelled man to lay by stores of food in summer for use in the winter. This increased activity, which is not demanded of the native of the torrid zone, is undoubtedly a factor in developing greater energy in man in the temperate zones. The progressive people today are those who plan for the future. Inventions and progress in science are in a way planning for the future. Can we say

that the inclination of the earth's axis is the basic cause of the invention of the airplane, the steam engine, or the radio? How important is the single fact of science that the earth's axis is inclined to the plane of the earth's orbit? It surely means much more than a person who has not thought the matter over carefully might suspect.

Ever since man appeared on the earth he must have unknowingly made use of the fact that the earth rotates once on its axis every 24 hours, for he could always distinguish the difference between day and night. Since the time of primitive man there has been a desire to mark the passage of time. You remember that Robinson Crusoe, after he was wrecked, cut a notch in a stick every day that he lived on his desolate island. The crude shadow-stick and the sundial were early devices providing the means of measuring the passage of time when the sun was shining, but at night or when it was cloudy, these devices were of no use. Eventually man learned to measure the day, the month, and the year by observation of the effects of natural movements of the earth and moon. Later he made devices for measuring smaller divisions of time. Such devices were the hourglass, the sun clock, the water clock, and our modern clock. The water clock had an advantage over the sundial because it would work when the sun was not shining. Our present hourglass runs on the same principle as the water clock, only sand takes the place of water. The hourglass was used as early as the eighth century A.D. Modern clocks date from the seventeenth century, when Christian Huygens, a Dutch mathematician, applied the pendulum to regulate the movement of clocks. Household clocks today are of



What was the advantage of the banded candle?

two types: the pendulum and the balance wheel. Power to drive the wheels comes from a spring, although in many old clocks falling weights were used to move the wheels.

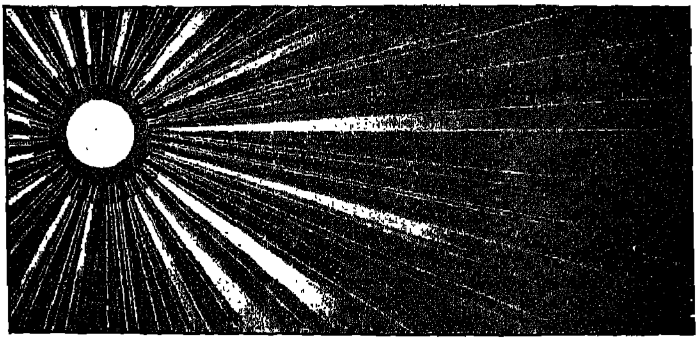
It is well to think over the main ideas of your work of last year, relating to heavenly bodies, to give you a review introduction to this present unit.

Science Principles

1. The stars are so far away it takes years for the light from them to reach us.
2. There are many more stars than we can see.
3. The rotation of the earth causes an apparent daily rotation of the stars.

PROBLEM I. HOW DOES MAN DEPEND UPON THE SUN?

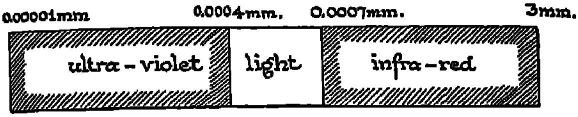
Our Star — The Sun. We may call the sun "our star" because it is the only one of the millions of stars that has any important relation to the earth. The sun is a huge globular mass of gaseous matter having a temperature above 10,000° Fahrenheit at its surface. It is estimated that at its center it has the unthinkable temperature of about 30,000,000° Fahrenheit. This



Find the earth in this diagram. What does it do to the rays from the sun?

condition of matter in the sun is evidence of the tremendous amount of energy it possesses. It is always radiating this energy in every direction, the earth intercepting but a tiny amount of it, one two-billionth of all the heat and light which leaves the sun.

Radiation across Space. All of the energy we receive from the sun comes in the form of radiations through space. These radiations are of the same general character but differ in their rate of vibration. The slowest

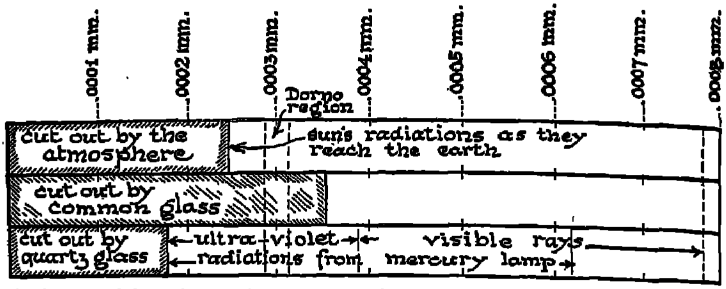


How much of this area do we see? How much do we feel?

vibrations are the so-called infra-red rays or heat rays, then the more rapid vibrations which affect sight and which are called light. Finally of still greater frequency of vibration are the ultra-violet rays which produce a tan and are so useful in healthful living. All these radiations travel faster than anything we know of, over 186,000 miles a second. We speak of this as the speed of light, and all of these radiations together are solar radiations. This band of rays is the solar spectrum.

Beneficial Ultra-Violet Rays. The rays beneficial to man come from a small "Dorno" region of the spectrum (see diagram, page 244). The rays of this ultra-violet area may be used for the treatment of rickets, tuberculosis, and some skin diseases. They appear to increase the alkalinity and amount of iron in the blood, and also increase the appetite. Quartz glass is used in some hospitals because it allows ultra-violet rays to pass through it. Cellophane also allows the ultra-violet rays to pass, but it is not durable enough for common use. In winter there is more fog, soot, clouds, and dust, all of which filter out the ultra-violet rays. The smoke over some of our big

cities lessens the quantity of helpful rays that we can receive, so that children have rickets and tuberculosis, and people show a low resistance to germs. In winter the rays are more slanting and pass through a greater depth of air. Wool clothing shuts out the ultra-violet rays, but loosely woven rayon or artificial silk lets them



The health-giving ultra-violet rays are chiefly found in the Dorno region. Why do we use quartz glass in the windows of some hospitals and homes?

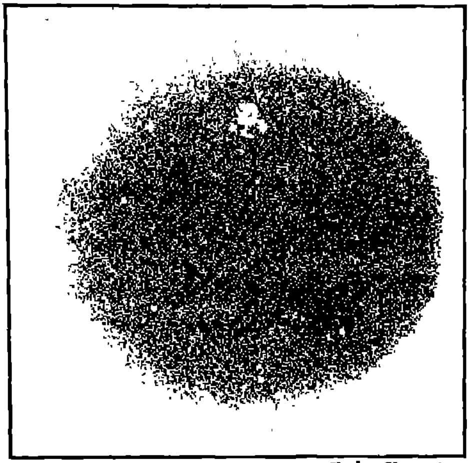
go through. Hence, women fare better than men today in getting the ultra-violet rays of the sun.

The Harm Sunlight Can Do. Sunlight gives us a sunburn before serious harm is done to the body and thus warns us of the danger. When one gets sunburned, he has had too much of the ultra-violet rays. It is just as harmful to be sunburned as to be burned with a hot iron. When the ultra-violet rays produce sunburn, whether from natural or artificial source, poisons are produced and cells are destroyed. Sunshine taken in proper amounts is beneficial, but there is danger from overdoses of it just as there is danger from overdoses of medicine. Red and amber glass filter out the ultra-violet rays. Diffused sunlight as well as direct sunlight will produce sunburn. Even a north exposure to the sky may give about one half as much sunlight as that of the southern exposure. Cold creams which are effective against sunburn contain fluorescent materials which absorb the ultra-violet rays. Arc

lights and mercury vapor lamps give out radiations shorter than those which reach us from the sun. It is not safe to use these radiations without your doctor's advice.

The reason that the paint on the northern side of houses remains in good condition longer than on the other side is because it receives less of the chemically active ultra-violet rays from the sun. Zinc-white is fluorescent and, when used in a paint, lessens the destructive action of sunlight. The sun's rays tend to weaken the oxidized oil and reduce the hardened paint to a brittle powder which "chalks" and wears off easily.

Sun Spots. The sun is composed of incandescent gases and does not seem solid like the earth. The sun's interior is immensely hotter than the outside. At times dense vapors are hurled upward from the interior and cool more quickly than the lighter gases and so appear as dark spots on the sun's surface. These are called sun spots. Some of them have a diameter of 25,000 miles. Records show that sun spots increase to a maximum every 11 years.



Yerkes Observatory

The earth could easily be put in one of these sun spots seen by the big telescope at Williams Bay, Wis.

The energy radiated by the sun seems to be greatest when the total area of the sun spots is greatest. This means that the heat of the earth is increased periodically. Sometimes the sun spots are large enough to be seen through smoked glasses with the naked eye, but they are

much more interesting when viewed through a small telescope or field glass equipped with smoked glass. It is by watching the movement of these sun spots that we know that the sun is rotating. But since the sun is made up of gases, it is possible for some parts of it to rotate faster than others. At the equator the period of rotation is about 25¼ days, but near the poles it is much longer. When sun spots are numerous, they appear to create electrical energy and interfere with our radio, telegraph, and telephone communication. They also seem to have some close relation to the Aurora Borealis or Northern Lights which are sometimes seen in the night sky of our northern continents.

Cause of Day and Night. Our day and night result from the earth's rotation, which brings us first on the side of the earth toward the sun and then on the side away from it. You will readily see how this is if you hold a ball a short distance from a lighted candle when there is no other light in the room. Rotate the ball and you will always see the part that is toward the candle is in the light and the part away from it is in darkness, or in the shadow cast by the earth. This explains our day and night.

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

chemicals	moon	harmless	destroyed	opaque
minerals	sun	useless	revolution	maximum
spots	day	earth	harmful	rays
stars	equator	deadly	axis	rare
lines	poisons	rotation	transparent	beneficial
minimum	created	radiate	luminous	electrical

The (1)____ is the chief source of heat and light on the earth. At times there are, on the surface of the (2)____, dark areas called (3)____ (4)____, which seem to send out (5)____ energy in amounts

sufficient to interfere with electrical communication on the earth. The sun seems to (6)____ more energy at the time of (7)____ number of sun (8)____. Not all ultra-violet (9)____ are (10)____ to human beings. Quartz glass is (11)____ while ordinary glass is nearly (12)____ to the (13)____ ultra-violet rays. Sunburns are (14)____ because the cells are (15)____ and (16)____ are produced. Our night and (17)____ result from the (18)____ of the (19)____. The (20)____ of the earth is inclined to the plane of its orbit.

ESSAY TEST

Francis Tells Why Ancient People Were Sun Worshipers

Read carefully and critically. List all the errors and suggest corrections.

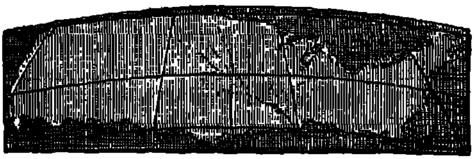
The two most important actions of the sun which were known to the ancients are the production of daylight and its ability to kill disease germs. There are other reasons why people today might worship the sun. The rainbow is nothing but sunlight transformed by raindrops. There are serious objections to sunlight. The best mental effort of man comes in the night when he works until one or two o'clock. Without sunlight in the daytime, there would probably be another period of increased mental output in what is now daytime. Sunlight gives sunburns and it is fortunate that many cities have clouds of black smoke over them so much of the time to protect the people. There are black holes on the sun big enough to hold many earths. These appear as spots and they are very cold. They radiate cold to the earth and that gives us our periodic cold spells. The movement of these spots indicates that the sun rotates on its axis. This causes our day and night.

PROBLEM II. WHAT CAUSES THE SEASONS

Causes of the Seasons. While the earth is revolving around the sun, its axis is inclined or tilted 23½ degrees to the plane of the earth's orbit. The axis always keeps a fixed direction pointing to the North Star. As a result, the north pole is inclined sometimes toward the sun and sometimes away from it. This relation of earth to sun causes our seasons. The United States intercepts a much larger number of rays from the sun in July than it does in January because the rays are more nearly vertical

in July. This difference in relative amounts of radiation furnishing energy which we receive from the sun at these two seasons is in proportion to its apparent size as viewed from the source of these rays. Study the two diagrams which represent views of the United States as it would appear in summer and in winter from a high elevation in the direction of the sun.

If the United States could be viewed from the direction of the sun in midsummer it would appear like this.



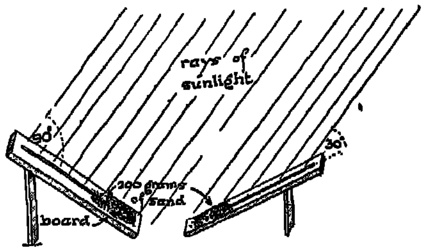
If the United States could be viewed from the direction of the sun in midwinter it would appear like this. How do you account for the difference?

When the sun's rays south of the equator are vertical on December 22, the radiation on one square mile in Rio de Janeiro, Brazil, is about equal to that on an area of two square miles in New York or Chicago. Other reasons for a colder season in winter than summer are that the period of daily sunshine is shorter and that the slanting rays pass through a greater thickness of atmosphere.

The distance of the earth from the sun is 3,000,000 miles less in January than in July. This tends to make winters north of the equator a little warmer and the summers a little cooler, but increases the heat of summers and the cold of winters in the Southern Hemisphere. Its influence, however, is small compared to that of the inclination of the earth's axis.

Demonstration 1. Why Are Vertical Rays Warmer?

Materials. Two half-inch boards, about three inches wide, and twelve inches long, having raised rim ($\frac{1}{4}$ inch) around the edge of one end and two sides; fine dry soil without lumps; two thermometers.

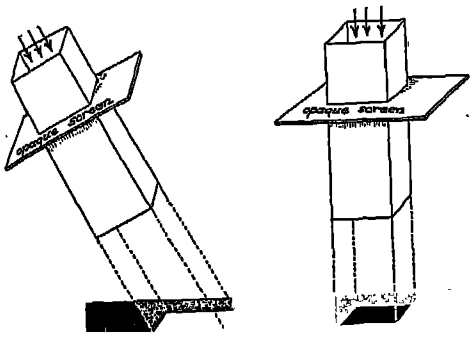


Method and Results. Lay a thermometer on each board and fasten it so that the bulb is not nearer than one inch to any edge. Spread equal amounts of dry soil over the bulbs, making smooth even layers of uniform depth. Arrange thermometers so that the two boards may be held in such a way that the sun's rays will come to one at an angle of 90° and to the other at an angle of 30°. Place them in bright sunshine at the same time.

If used indoors, it is well to open the windows and thus increase the radiation. If cloudy, an electric heater or a 400-watt lamp may be used. After ten minutes read the temperatures. What is the temperature of the soil which has received the direct rays of the sun at an angle of 90°? Of the soil which received the oblique rays at an angle of 30°?

Conclusion and Explanation. Draw a conclusion and give a reason for the fact demonstrated.

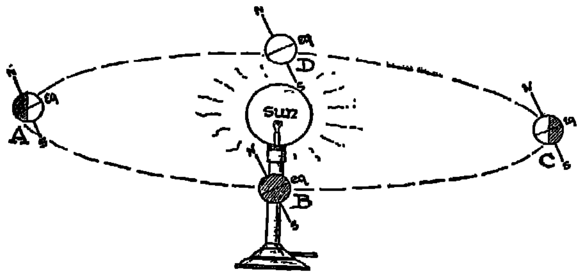
Why Are Direct Rays Hotter Than Oblique Rays? This diagram shows beams of light of the same diameter. Note the size of area covered by the beam which comes at an oblique angle to the surface. Note the area covered when the beam meets the earth perpendicular to the surface. Which covers the larger area? Both beams bring the same amount of



light and heat from the sun. Will the intensity of light and heat be the same? A second reason for greater intensity of heat from the vertical rays is that the beam passes a shorter distance through the atmosphere of the earth and consequently suffers less loss from absorption by the air.

Demonstration 2. To Show the Length of Day and Night.

In the center of a darkened room place a bright light on a small table. Let this lamp represent the sun. Place a slender stick or knitting needle through an orange or ball to represent the earth

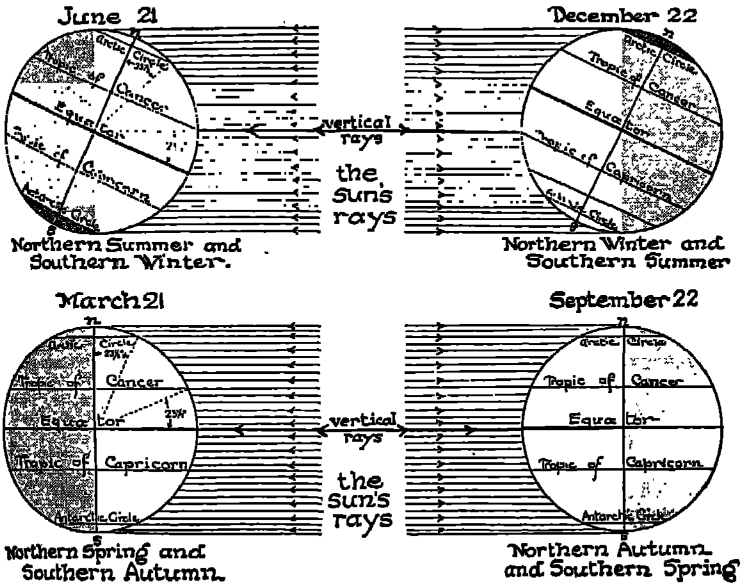


and its axis. Place a thumb tack on the orange to locate the place where you live. Tip the axis of this earth in position *A*, so that the direct rays of the sun make an angle of about 23½ degrees with the plane of the earth's equator. Rotate the earth about this axis. If you cannot easily estimate the relative time your home (marked by the thumb tack) would be in the lighted area and the darkened area, stop the rotation and place two pins at the two boundaries of the lighted area on the circle you have marked through the thumb tack. Measure the distance between these on the lighted area, and again the distance between these on the darkened area to see whether that part in the shadow or that in the light is the longer. Do you have a longer day or night at *A*? Does it represent the earth's position in summer or in winter? Make similar tests in positions *B*, *C*, and *D*.

Why Our Days Differ in Length. The experiments show why the farther one goes north of the equator in the summer, the longer the period of daylight, and that the north pole is in daylight continually. In the spring

and autumn we have equal-length days and nights, for then the sun's rays are vertical at the equator. During the part of the year when we have the shortest days, the north pole is in continuous darkness, but the southern regions, south of the equator, have conditions like ours in summer.

Variation in Duration of Daylight. As the earth revolves around the sun, its axis points all the time towards the North Star. The axis is inclined to the plane of the earth's orbit, making an angle with it of 23½ degrees. As a result (see diagram), on March 21 and September 22, when the earth's equator and the plane of the earth's orbit intersect at a point in line with the sun, the vertical rays of the sun will be on the equator. At this time both north and south poles will receive light and the days and nights will be equal. About December 22 the direct



Read your text and then explain the relation of our seasons to the vertical rays of the sun. How does the length of our daylight depend upon the season?

rays of the sun will reach the earth 23½ degrees south of the equator. The south pole will be in sunlight day and night. The duration of sunlight north of the equator will be less than 12 hours. The north pole will receive no light at all. Study the diagram and explain what change will be brought about when the earth has reached a point in its orbit which it occupies on June 21. Do you think they have winters in the Southern Hemisphere? Explain.

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange the words in proper numerical order. A word may be used more than once.

January	March	June	September
east	west	south	north
less	more	Polar	winter
inclined	least	slanting	equator
almost	straight	vertical	orbit

The axis of the earth is always (1)____ to the plane of the earth's (2)____ and always points to the (3)____ star. As a result of these facts, the (4)____ rays from the sun are sometimes 23° north of the (5)____ and in our (6)____ season they are south of the equator. Vertical rays from the sun give (7)____ heat than (8)____ rays. In December the (9)____ pole is having sunlight day and night, but no place (10)____ of the equator is having sunlight as long as twelve hours. We have days and nights of equal length in (11)____ and (12)____.

ESSAY TEST

JASON EXPLAINS THE CAUSES OF SEASONS

Read carefully and critically. List all the errors and suggest corrections.

The North Star keeps the axis of the earth pointing in that direction at all times. The axis is continually inclined to its orbit. There are only two times a year when this is not true. In March and September rays of the sun are vertical at the equator because then the axis of the earth is at right angles or perpendicular to its orbit. The tilting of the earth causes a very peculiar thing, as you can

see by looking at the illustrations of the United States on page 248. In summer the United States is much larger than in winter. This is due to the greater heat that causes it to expand. The reason direct or vertical rays are hotter than oblique or slanting rays is that they strike a surface harder; the slanting rays strike a glancing blow and anyone knows that is less effective. The principal reason why days are longer in summer than in winter is that the rotation of the earth is slower in summer. This gives the sun a longer time to shine on us.

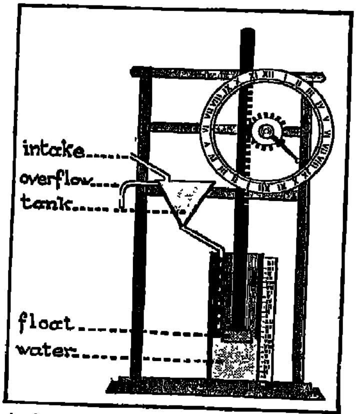
PROBLEM III. HOW WE TELL TIME

What time is it? This is a very simple question and one that we can answer today by a glance at our watch or clock. But did you ever consider how time came to be told accurately? It must have been a long, long period before the savages who inhabited the earth in former days came to know anything about periods of time. The rising and setting of the sun, the full moon, and the coming of hot or cold seasons, short days, and certain groupings of stars in the sky at night, after many long years must have impressed man so that he began to have some sense and appreciation of time. But for many thousands of years no real account of time was kept. Perhaps the first division of the day was made by measuring the length of the sun's shadow at the back of a stick or against some plane object. Then came the sundial and the water clock.

How may a wall dial or a garden dial be used to tell sun time?

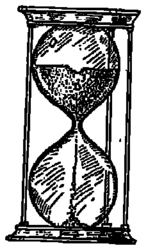
Sundials. The passing from a timeless world to one in which primitive reckoning devices were used marked

progress. The first record of the use of a sundial is found in a Chinese manuscript written about 1100 B.C. Even the sundials were subjected to great improvement as they evolved from the earliest forms to the later ones. A sundial with its style (the post that makes the shadow) pointing to the North Star will give shadows which do not vary with the seasons. The hour spaces are not equally spaced, those about the noon hour being nearer together.



A clepsydra or water clock. Explain how it can keep time.

Types of Water Clocks. Various water clocks have been in use in many different countries. Time is measured by the flow of water through a tiny opening. In one type the vessel was floated in water and time was recorded by the level of water that came into the vessel. More common types measured the emptying time of a vessel of water. More elaborate clocks, like the clepsydra, had a floating rod which meshed into a cog wheel and would turn a pointer around a scale upon which the hours were marked.



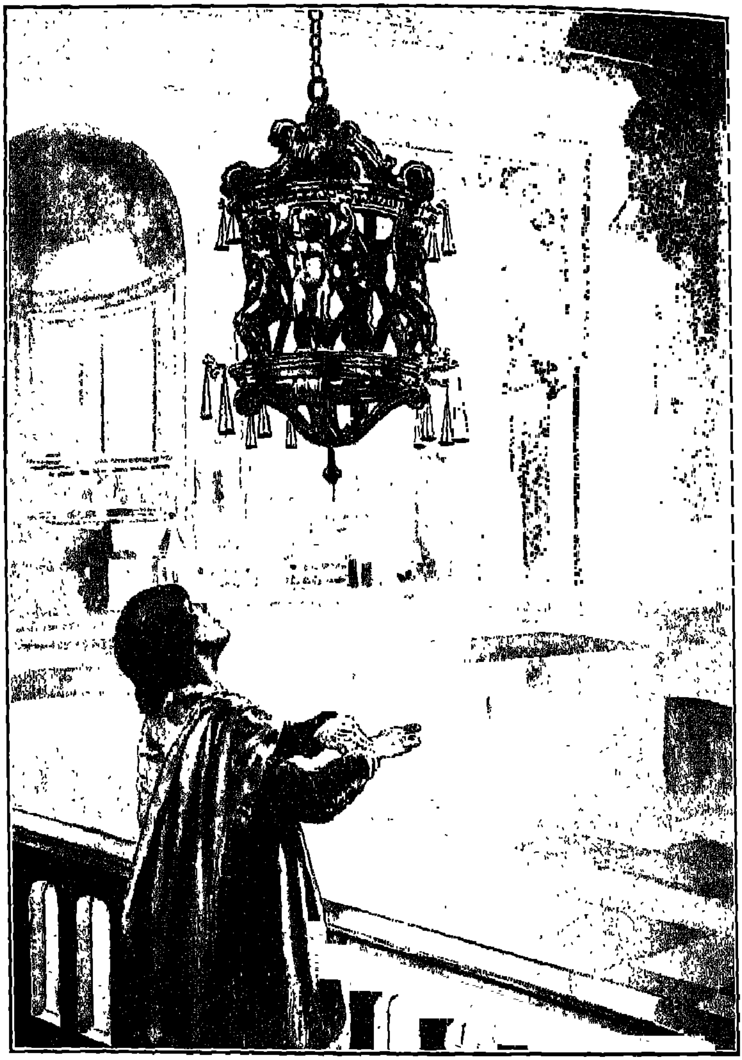
How is time measured by this hourglass?

Other Timing Devices. Another timing device, the hourglass, thought to have been invented by the Greeks, uses the same principle as one form of water clock. A portion of sand escapes within a definite time. The burning of knotted grass strings — the knots equally spaced — and of candles marked off into equal spaces, have served as timekeepers. It was not until

about the thirteenth century that rude clocks were used. They were operated by falling weights and hands moving over a dial were used. But these early clocks lacked a good device to keep the motion uniform. The oil-time lamp which was used in Europe about 1500 years ago measured time by the fall in the level of oil in a reservoir.

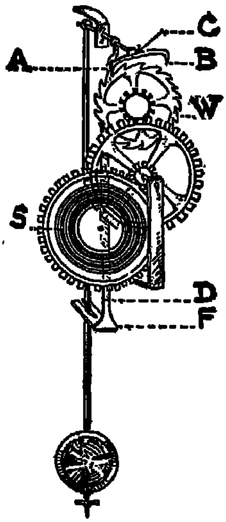
Galileo and the Pendulum. Probably all of you have read the story of Galileo seeing a chandelier in the cathedral swaying back and forth. Thousands of others had seen the same thing, but it stimulated Galileo to thinking. The chandelier seemed to move back and forth in equal periods of time. How could he prove that this was true? He thought of his pulse; that was regular, and he timed the swingings by feeling his pulse. The chandelier swung through a short arc and through a long arc in the same interval of time. Galileo also found in experimenting at home afterward that by varying the length of the string supporting a swinging body, he could change the time of the swing. He invented a device for recording the pulse beats of a patient by means of a rotating pointer moved by a swinging pendulum that was made to coincide with the pulse beat. But it was not until after Galileo's death that Huygens conceived the idea of utilizing the pendulum for keeping time in a clock.

Modern Time Pieces. The modern clock, using a pendulum, is less than 300 years old. The first watch was made in Nuremburg, Germany, in the fifteenth century. The name "watch" comes from the fact that night watchmen carried these time pieces for calling off the "watches of the night." Our cheap alarm clocks of today are far more accurate than the best watches of early times, but with new improved devices for keeping uniform movement, our watches and clocks of today are capable of keeping very nearly perfect time. In 1658 the balance wheel with the "hair" spring used in the modern watch



One day when he was only nineteen Galileo happened to notice the swinging of a great lamp in the cathedral of Pisa. He timed its movement by means of pulse beats. To his surprise he found that the lamp took as long to complete a swing when it was moving violently as when it moved slowly. From this discovery he got the idea that a pendulum might be used for the measurement of time.

was invented. In 1765 came the lever escapement, and with it a great improvement in the time-keeping qualities of the watch resulted. The Swiss were the first people to manufacture watches on a large scale in factories. But today large factories are found in many different countries.



Read your text and give the use of *A*, *B*, *C*; of *W*, and of *S*.

Common Clocks. Two types of clocks are in use today, the pendulum type and the balance-wheel. The power to drive the wheels is derived from the mainspring, although in some old-fashioned clocks, weights are used as they were in the earlier clocks. The pendulum clock must be kept upright. This is not necessary with the balance-wheel clock or the watch. The purpose of the pendulum or the balance wheel is to obtain uniform speed. Working with these is a very important device known as the escapement. It is through this that the pendulum or the balance wheel controls the speed of the train of wheels in the works of the clock. It is also through this that the mainspring gives the force which keeps the pendulum and the balance wheel from stopping.

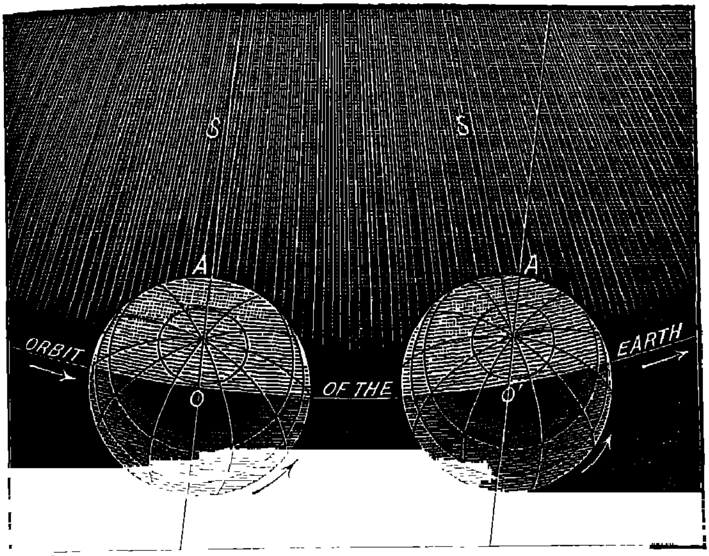
Electric Clocks. You may have wondered how your school clock keeps time. If you have the usual type, you have noticed that the long hand jumps ahead once every minute. It is controlled by a master clock which closes an electric circuit once a minute and sends electricity through the wires which enter each classroom clock. When the electromagnet in the clock receives this energy it pulls an armature that turns the clock's hands. In your home you may have a different type of electric clock. In

it is an electric motor that runs on an alternating current. Most of the clocks are made for currents of the 60-cycle type and will not keep time correctly unless the current from the power house is kept steady at the proper rate of the alternation.

Checking the Accuracy of Clocks. Time keeping depends upon constant uniform motion. The earth itself is a body with uniform motion. Its time of rotation upon its axis is the same now as when the Chinese first used a sundial, and as it was when man lacked every artificial means of reckoning time. The astronomer tells us that the earth is so regular in its rotation upon its axis that its motion does not vary one second in 100,000 years. This fact is made use of by the United States Naval Observatory in checking the accuracy of its clocks.

Sidereal Time. The time it takes for the earth to rotate and come again to the same position with reference to a certain star is the *sidereal day*. You have learned that great circles passing through the poles of the earth and crossing the equator are meridian circles. If we have a telescope which can swing in a north-and-south line only, we can observe when a given star crosses that line. The time that elapses between two successive passings of the star across the meridian is a sidereal day. Since it is rather easy to take observations on the stars, our standard clocks are astronomical clocks which keep sidereal time.

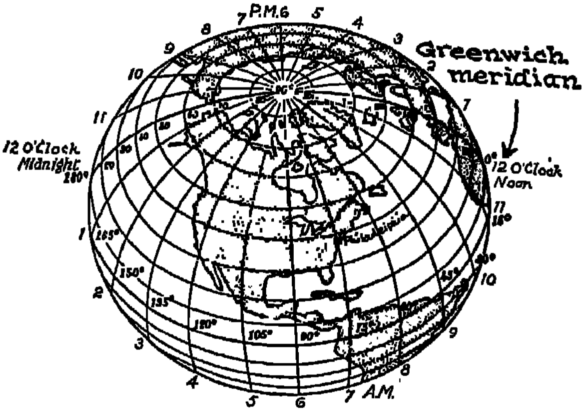
Solar Time. True solar time is the interval which elapses between two successive passings of the sun across the same meridian circle. This day varies with the season, but the yearly average is the mean solar day which we use. This is divided into 24 hours. The mean solar day is 3 minutes 56 seconds longer than the sidereal day. No two cities, unless they are under the same meridian circle, can have the same solar time.



A sidereal day is the time consumed by the point *A*, on the equator, in going round in the direction of the arrows and returning to the starting point. Since the earth is revolving in its orbit, a star seen in the direction *OAS* in the beginning would be in the direction *O'A* after the earth has turned around. A solar day is not complete until the earth has turned around sufficiently to bring *A* directly under *S* (sun).

Standard Time. In two cities using sun or solar time, it could not be twelve o'clock at the same instant if one city were farther west than the other, since the rays of the sun would not strike both cities at the same angle. If each city used its own local sun time, every traveler going east or west would need to change his watch one minute about every thirteen miles. This would be a great inconvenience to business and to railroads. To overcome such hindrances certain time belts have been agreed upon which use *standard* time. At any given instant all places within a given belt will have the same time, and two adjacent belts will differ by one hour. This system has been adopted throughout the world, and we speak of it as standard time. Standard time is a geographic arrangement of mean solar time devised to meet the needs of

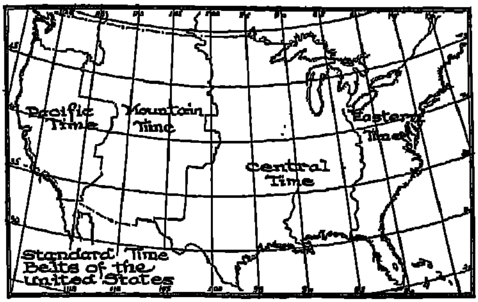
an industrial and commercial world. The sidereal time can be changed by simple calculation to our standard time, which is sent out by telegraph and radio every day from the Naval Observatory in Washington, D. C., and from the Mare Island Navy Yard in California.



Why is the Greenwich meridian so important in telling time? What difference in time exists between Greenwich and Philadelphia? Why?

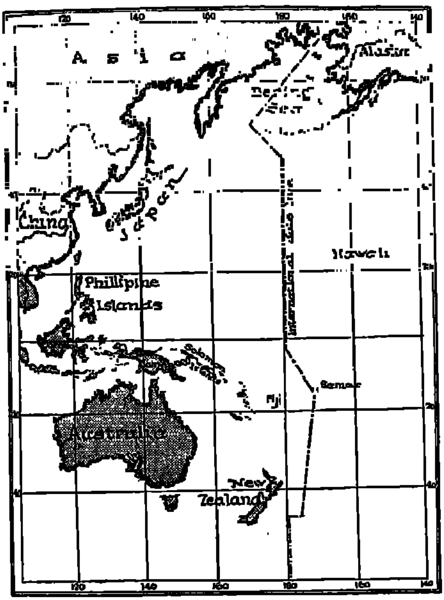
Time Zones or Belts. The day is divided into 24 hours. For convenience in measuring, the circle representing the equator is divided into 360 degrees or parts, and each point is connected to the north and south poles, making 360 imaginary circles or meridians. These meridians indicate the degrees of longitude. The meridian which passes through Greenwich Observatory, England, is marked 0° and is called the first or prime meridian. From this point, the meridians are numbered both east and west from 0° to 180°, making 360° in all. Every fifteen degrees (360 divided by 24) either east or west marks the end of a time zone or belt and represents a difference of one hour from the preceding zone. The time in the zone east is one hour later and in the first zone west is one hour

earlier than the time at Greenwich. The seventy-fifth meridian passes through Philadelphia. Philadelphia is at the center of the fifth time zone west of Greenwich and the time in Philadelphia is, therefore, five hours earlier than Greenwich time. The zone boundaries in the United States are not exactly in line with the meridians. Local conditions near the borders of zones determine in which time zone a certain town or section will be classed. The standard time zones for the United States are indicated in the diagram.



What is the difference in time between Boston, Massachusetts, and San Francisco, California?

International Date Line. If in one day one were to travel west around the world and set his watch back one hour for every new time zone he passed through, he would lose twenty-four hours, or one day, in his journey. If he traveled east instead of west, by setting his watch forward one hour every fifteen degrees,



When it is noon in London what time is it at the international date line?

he would gain one day. To avoid confusion it is essential that the addition or subtraction of a day be done at the same place for all travelers. So a standard has been adopted by all the countries of the globe. The one hundred eightieth meridian, which passes through the Pacific Ocean directly opposite Greenwich, is called the international date line. Some irregularity in this line is made to prevent making two different days for people living on the same group of islands in the Pacific Ocean. When you come to this line sailing west from America to Asia, you drop out a day. That is, if you reach it on Sunday, you call the day Monday. When sailing east, if you reach the line on Sunday, you call the day Saturday.

The following clipping from a newspaper gives an account of the change in time when the *Graf Zeppelin* first crossed the international date line going east, in August, 1929.

> **_GRAF_ PASSENGERS GO TO BED TONIGHT, GET UP THIS MORNING**
>
> Passengers on the *Graf Zeppelin* will experience a strange moment in world travel when they cross the place where "the day begins," the international date or calendar line. This is the 180th meridian, in mid-Pacific.
>
> The crossing probably will be tonight, and the airship will gain one day, doubling the day she crosses the meridian. The *Graf's* passengers will go to bed Saturday night and wake to find it Saturday morning again. If the line is crossed Sunday, there will be two Sabbaths.
>
> If the flight was in the opposite direction, a day would be skipped altogether. Going to bed Saturday night, passengers would wake to find it Monday.

Daylight Saving. Daylight-saving time, used by many states and cities in summer, is obtained by setting the

clocks one hour ahead of standard time. Sunrise and sunset are, therefore, one hour later than that indicated by clock time. The change of business hours in the summer months makes it possible for all people to utilize the period of light which comes early in the morning. It also gives the workers a longer evening for recreation. The plan has much in its favor although it has met with some opposition from farmers and others who do not stop work until sunset. It makes a considerable saving in fuel and light.

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

thirty	Huygens	39.1	accurate
international	Newton	fifteen	hour
surface	Galileo	one	keeping
inaccurate	Edison	twelve	dial
longer	line	dropped	true
shorter	earth	weights	uniform

Early methods of (1)____ time were not (2)____. The movement of hands over a (3)____ operated by (4)____ did not have (5)____ motion until the pendulum discovered by (6)____ and applied to clocks by (7)____ was used. A sidereal day is (8)____ than a mean solar day. Belts differing by (9)____ (10)____ in time from one belt to the next surround the (11)____ approximately every (12)____ degrees of longitude. If traveling west, a day is (13)____ out when you come to the (14)____ date (15)____.

ESSAY TEST

Arno Has "Read Up" on Time Keeping

Read carefully and critically. List all the errors and suggest corrections.

"Does your watch keep good time?" someone asked me recently. I replied that there is nothing that can keep time good or bad. Time continually progresses in one direction; it cannot be halted or reversed. It is the passage of time that we try to measure with our timepieces. Until modern clocks were invented the only

way man could keep track of time was by the sun or a shadow stick. The accurate clocks of today would be impossible if it were not for the pendulum. Pendulums cannot be used in watches because of their size; instead, a device called the balance wheel vibrates and causes the motion to be uniform. Electric clocks require a mainspring to drive the wheels but use an electric current instead of a pendulum to keep uniform motion. We get our time from the stars and call it sidereal time. The reason why the time differs so much in different parts of the world is that there are so many stars from which they get their time.

THE REVIEW SUMMARY

In preparing a summary of what you have found out in this unit, you will want to place emphasis on the big ideas which have come from the applications of the facts you have learned and the demonstrations you have seen. Doubtless you have done some additional reading which has helped you put together some of the facts into generalizations or fundamental underlying principles. For this unit some of these generalizations are:

1. The sun sends out a variety of radiations, many of which benefit man.
2. The passage of sun spots across the sun's surface is regarded as evidence of its rotation.
3. Seasons result from a change of position of the direct rays of the sun on the earth's surface.
4. Passage of time is measured by devices having uniform motion.
5. Standard time is a method of time measurement agreed upon to avoid confusion. Can you add any to this list?

Before making your review summary for your workbook, test your knowledge of the facts of the unit by checking over the text so as to be sure you know the facts underlying the science principles or generalizations. Then using this material and everything you have read, seen, or done yourself, make your summary outline. This outline you may use when you make a recitation.

TEST ON FUNDAMENTAL CONCEPTS

In a vertical column under the heading CORRECT *write numbers of all statements you believe are true. In another column under*

INCORRECT *write numbers of all the false statements. Your grade = right answers* $\times 3\frac{1}{3}$.

I. **Changes in seasons are desirable so that:** (1) we may use changes of clothing; (2) we may have more energy; (3) we may have a greater variety of fruit and vegetables; (4) we may have ice for skating; (5) we may keep from getting too hot.

II. **Among the causes of the seasons are:** (6) the earth revolves around the sun; (7) the axis of the earth is inclined to the orbit; (8) the sun's rays vary in directness; (9) the rays coming to one place on the earth do not always come through the same amount of air; (10) the length of daylight at a given place changes.

III. **Standard time makes use of a day determined by:** (11) the rotation of the earth from one transit of the sun to the next; (12) rotation from one transit of a star to the next; (13) two consecutive transits of any planet, for example, Venus; (14) agreement as to the mean solar day; (15) the rising and setting of the sun each day.

IV. **The following are important facts about time:** (16) daylight-saving and mean solar time are the same; (17) standard time means sidereal time; (18) if you cross the international line going west on Thursday, you call the day Friday; (19) if your watch indicates daylight-saving time in New York and your friend has his set to standard time in Chicago, the two watches will read alike; (20) news of an event which happened 5 P.M. standard time in London may be printed in newspapers and on sale in New York at 4 P.M. the same day.

V. **A pendulum clock has:** (21) a balance wheel; (22) either a mainspring or a weight to keep it running; (23) a hair spring to regulate its speed; (24) no way to change its speed; (25) an escapement wheel.

VI. **A balance-wheel clock:** (26) needs a very short pendulum; (27) may have a mainspring; (28) must have a hair spring; (29) has a rocker arm; (30) is regulated by changing length of pendulum.

PRACTICAL PROBLEMS

1. Why did Admiral Byrd select December rather than June for his flight over the South Pole?

2. Make diagrams to explain why the sidereal day and solar day are not exactly alike. Remember that the earth travels about 1,600,000 miles a day in its orbit around the sun and that the sun, being only 93,000,000 miles away, is *near* the earth when compared to even the nearest of the stars, which is 25,000,000,000,000 miles away.

3. A person in New York, who happens to be talking to a friend in Australia by radiophone, looks at his watch and the calendar and remarks to his friend, "It is now just 7 P.M., December 31, 1935." His friend immediately replies, "You are wrong, for according to my watch and calendar it is just 10 A.M., January 1, 1936." Explain how both may be right.

4. When it is 10 A.M. Thursday, standard time, in Chicago, what time is it (*a*) daylight-saving time in New York? (*b*) standard time in San Francisco? (*c*) standard time in Honolulu? (*d*) standard time in Wellington, New Zealand? (*e*) standard time in Manila?

5. Can the sun ever be seen at midnight?

INTERESTING THINGS TO DO, READ ABOUT, OR SEE

1. Twilight in different parts of the world at different seasons.
2. Do we need a new calendar? Reasons for and against.
3. History of our calendar.
4. Cause of perpetual snow and ice at the poles.
5. Why our forenoons do not always equal our afternoons.
6. Ultra-violet rays and health.
7. How to get a tan without a sunburn.

SCIENCE FOR LEISURE TIME

1. Dinner Time for One at the North Pole

Suppose four men living respectively in New York, Chicago, Denver, and San Francisco agree to start north at the noon dinner hour. Suppose it is possible for them to continue to travel northward each along the meridian circle of the city from which he starts. Each day at noon he has his dinner.

(1) Where will these four men meet?

(2) Soon after they meet, the man from New York looks at his watch. It is 12 o'clock and he says, "Gentlemen, it is now dinner time, shall we eat?" What are the others likely to reply?

(3) Which one has the correct time for the North Pole?

(4) If each sets his watch to agree with the one carried by the man from Chicago and then returns to his home city, how will his time compare with the correct time at his home? Answer for each of the four men.

2. Measuring a Sidereal Day

Locate a brilliant star towards either the east or west. Arrange a pea shooter with clamps to keep it securely in place. Adjust

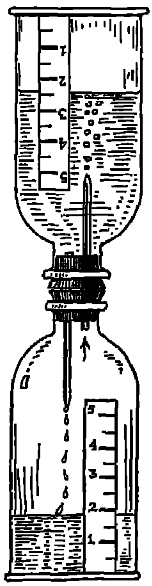
it so you can just see the star through it. Record the time by a correct timepiece. Sight through the pea shooter just a little earlier the next evening. When the star appears, record the time. The time that elapsed between the two readings is a sidereal day. How does it compare with a day clock time?

3. Motion of Pendulum

Tie a button to the end of a thread. Fasten the string 6 inches from the button and set it to swinging. How many times does it swing per minute? Fasten it 12 inches from the button. How many times does it swing per minute? How does the length of a pendulum influence its rate of movement?

4. How to Tell Direction with a Watch

Hold the watch horizontally in hand. Place a pencil close to edge of watch vertically in front of point of hour hand. Move watch and pencil until pencil shadow coincides with the hour hand. Then halfway between the point of the hour hand and 12 on the watch dial is *south.*



SCIENCE CLUB ACTIVITIES

1. Make a Water Clock

The diagram will suggest how you can make a water glass on the principle of the sand glass. The time it takes the water to run from the top bottle to the lower one depends on the size of the opening left in the ends of the jet tubes and the amount of the water. With an 8-ounce bottle you can easily make a 3-minute glass; with a 16-ounce bottle you might make a 5-minute glass. Mark on a scale the level for minutes and half minutes. Invert the clock each time to start action.

2. Make a Sundial

The sundial consists of a horizontal dial and a shadow-making style or gnomon, as it is called. The gnomon cut from metal or wood is triangular, having the smallest angle equal to the degrees of latitude of the place where it is to be used. The gnomon is fastened to the dial, with the small angle to the south and on the center of a base east-west line. Place so the gnomon is in a true north-south line. Use compass, making correction for North Pole, or sight it towards

North Star in the evening. Mark scale by test, noting shadow line every hour. The scale can be marked off by mathematical calculation, but for this you will need to consult reference.

3. Sun Spots

Try to arrange with some one who has equipment for seeing the sun spots an opportunity for members of the club to see the sun spots.

4. A Clock Census

Members of the club will see what types of old and new clocks they can find at home or borrow from friends. A committee will take the "census" to learn what different kinds are available. They then request certain ones to bring clocks to a meeting and to explain the outstanding features of the clocks. Get as large a variety of types as possible.

5. Time around the World

In order to understand how the time varies in different parts of the world draw a large circle at least 2 feet in diameter on the blackboard. Mark the center of the circle "North Pole." Consider this a map of a portion of the northern hemisphere. Add several curved arrows to show the direction in which the earth rotates on its axis. For any place on the earth the arrow head is pointing east.

At the extreme right hand of circle mark a spot to represent zero longitude or Greenwich. At the extreme left of circle mark the International Date Line (180° longitude). Then mark points on the circle representing east longitude 90° and west longitude 90°. Divide the circle of each quadrant thus made, into six parts that are equal. The whole circle will now be marked off into sections representing differences of longitude of 15°. Each section will represent how much difference in time?

Mark each of the 24 points of longitude. Assume that the time zones are evenly divided as are the meridians of longitude. Mark the time at Greenwich 12 o'clock noon. Mark the clock time for each of the marked points on the circle. Remember to use A.M. for those places whose time is before noon, and P.M. for those whose time is past noon when it is noon at Greenwich.

Make a line which will be vertical for people in Greenwich (extending to the right in diagram). Make other lines parallel to it to show the sun's rays on the whole half circle of the earth. If the time of year is September 22, where on this map will people be having sunrise? What time will it be? Where will they be having sunset? What time will it be?

At the moment of time shown, will it be the same day of the week everywhere on the earth? Mark 165° E. *A*, 180° *B*, and 165° W. *C*. Suppose the earth turns so that point *B* has moved to *C*. How will the time for people living there be changed? If the day begins at longitude 180° will there be a change in the day of the week as well as in the hour of the day? Think out the result of crossing the date line as one travels east or west.

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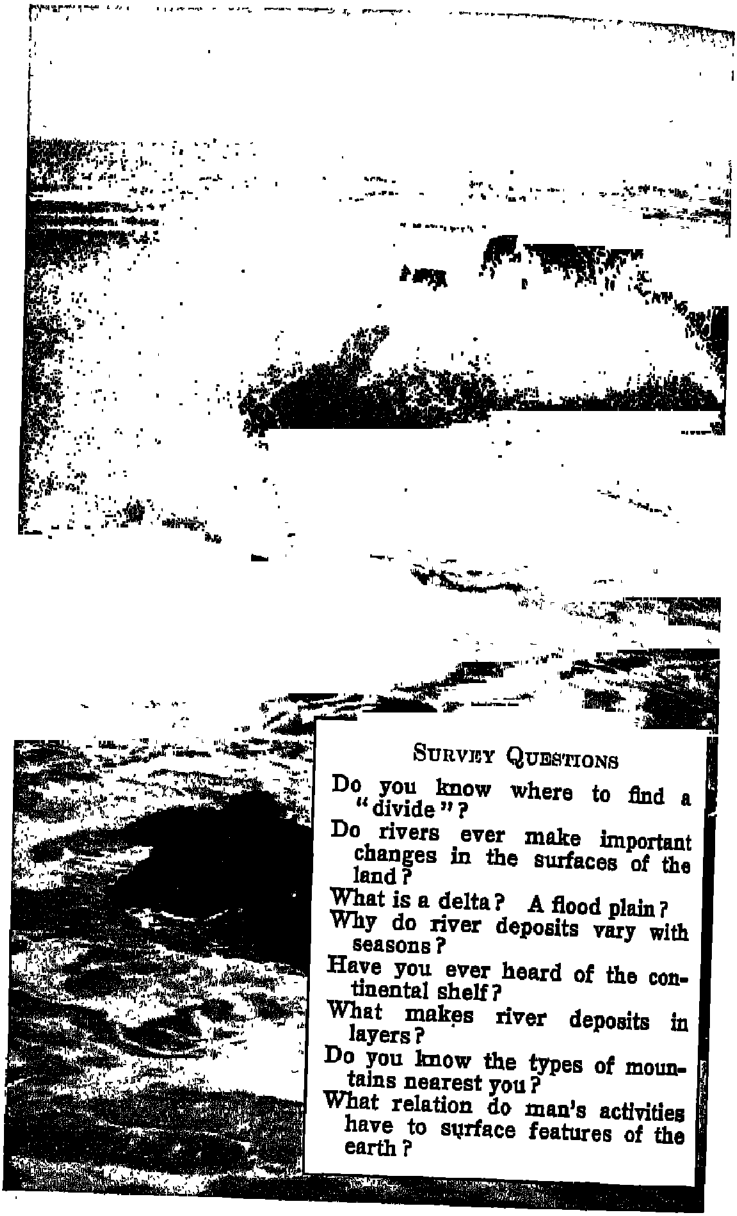


SURVEY QUESTIONS

Do you know where to find a "divide"?

Do rivers ever make important changes in the surfaces of the land?

What is a delta? A flood plain?

Why do river deposits vary with seasons?

Have you ever heard of the continental shelf?

What makes river deposits in layers?

Do you know the types of mountains nearest you?

What relation do man's activities have to surface features of the earth?

Earl J. Baird

UNIT X

HOW THE EARTH'S SURFACE INFLUENCES MAN'S ACTIVITIES

PREVIEW

Any girl or boy who has climbed to the summit of a hill or a mountain knows the feeling with which he looks out over the expanse below. We are alert to pick out this or that familiar landmark; we spy out forests here and fertile fields there, a lake nestling among the hills, a little town or river in the valley, perhaps a big city far off on the shore of some large body of water. We have that feeling of elation which comes to all after having accomplished something worth while, and we feel that the world spread out below us is a wonderful place to live in. How many of us, do you suppose, think back into the past and ask, "How did all this rock and soil come into existence? Were they always just as they are now? Or did the earth grow and change, much as the living things do?"

Regardless of how the earth was formed, it is a fact that a large part of the rock material we find upon or near the earth's surface has been at some time in a molten condition. It is possible that in some remote age volcanoes were active over a large part of the earth's surface. We may imagine a landscape full of huge craters, of great irregularity, a vast wilderness without living forms. It was this bleak, lifeless earth that has been transformed into the beautiful world covered with vegetation that we know. At some time, water was condensed and filled

the natural depressions or basins in the rock. The movement of water in its never-ending cycle has wrought important changes in the surface of the earth, and these changes are taking place today. Volcanoes, earthquakes, and great floods often make rapid changes in the earth's surface; but all the time there are the slower changes brought about by the action of wind, water, heat, frost, ice, snow, plants, and animals. These agents are constantly at work changing the rock to soil, changing the contour [1] of the surface of the land and deepening rivers and oceans or filling them in.

A contour map. Is this a level area?

We know something of the changes that have taken place in the earth since the time it was a young planet without life. The story of how mountains and valleys were formed, of how great rivers cut down mountains and carried them away to the ocean, of how water spread out great masses of earth to form the fertile plains of today, and of how the great lakes and harbors came into being will be told in this unit. We shall learn as well how man has come to use these land forms as sites for his great cities, his fertile farms, or his safe harbors. The pages that follow will help us to know more about some of these things.

The details of weathering, erosion, and soil formation are not given in this unit, having been given in *My Own*

[1] A contour line is one that passes at the same level through different places.

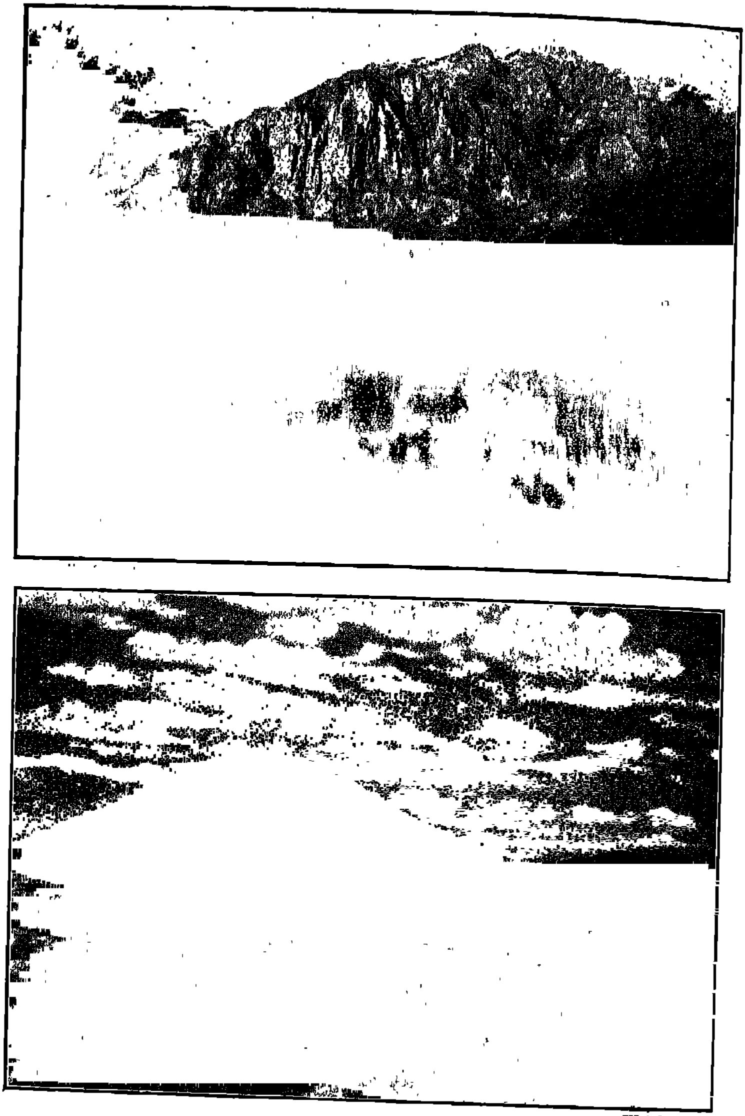
Science Problems, but they are important as a basis of understanding the work done by rivers. Check your knowledge on the following:

Science Principles

1. The surface of the earth is being changed all the time by the agents of weathering and erosion.
2. We can identify many changes as of ancient origin and others of recent origin.
3. Fossils give us information about much of the life on the earth millions of years before the arrival of man.
4. Soil is composed of fragments of rock.

PROBLEM I. HOW WERE MOUNTAINS FORMED?

Forces Acting within the Earth. Our ideas concerning the structure of the interior of the earth have been much changed in recent years. There is evidence from borings made into the earth's surface, from hot springs and volcanoes, that the interior of the earth is very hot. So hot indeed that were it not for the great pressure of the rocky crust it would be liquid. Gravity is a factor in creating the pressure that holds the material inside the earth in a more or less rigid form. Nevertheless, it is not believed to be so rigid but that it may change its form to some degree. The pressure of the huge ice cap that covered parts of North America during the glacial period probably pushed the crust of the earth down under it and there was an equal rise or bulging somewhere else. The deposits of eroded material brought down by rivers to the ocean along the coast may produce a downward force, while the removal of material from mountains relieves the pressure so that uplift in a mountain area may be equal to the loss from erosion. This warping may be very gradual and may result in variation of the relative levels of land and water along the seacoast.



Wright Pierce

Two types of mountains. The upper picture shows a glacial carved side of the granite rock mass of Mount Whitney, the highest of the Sierras. The lower shows a cinder cone in the Mohave Desert. It was probably an active volcano not more than 10,000 years ago. Would this mountain ever be as high as the one in the upper picture? Give your reasons.

have a rubber ball filled with water, when you press down in two widely separated places there is an elevation produced between them. The forces acting to restore balance between large areas may cause a folding or crumpling of layers of rock not far below the surface. This folding may result in a long elevated ridge roughly parallel to the coast line. We find many of our mountain ranges today have just such a relation to the coast line. Look at a map of the western coast of North and South America if you wish to see an example of this. When readjustment takes place over large areas, instead of folding into a mountain ridge, a large flat area may be elevated, producing a plateau as is found in Utah and Nevada.

Other Types of Mountains. Besides the slow growth of long ranges of mountains just described, there are some ways which are very rapid. Volcanoes may throw out volumes of volcanic ash or flowing lava and thus build volcanic cones. After the explosion of Mt. Pelée in 1902

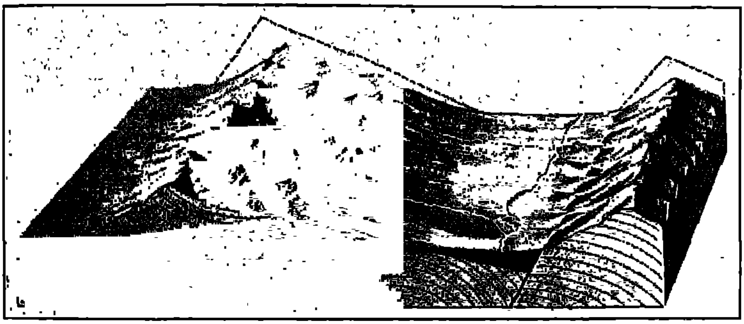


Diagram to show how block mountains are formed by faulting. Can you see why the mountain range is formed along the fault lines shown in the model?

the solid lava in the crater began to rise and within a space of seven months this mass of solid rock rose to a height of 1000 feet. It is believed that as the lava was pushed slowly upward, it solidified, so that its surface was always solid rock.

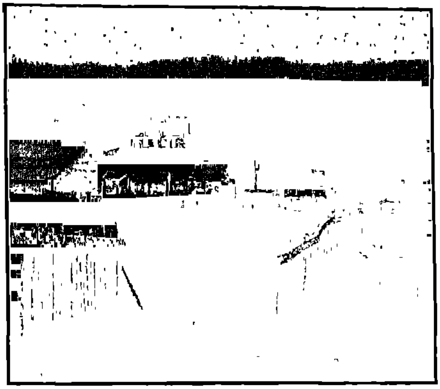
Another type of mountain is called the block mountain. In many parts of the west, the country is formed of great blocks of underlying rock which are separated by cracks or faults. When one side of the fault line is raised and tilted, a block mountain results. Many of the western mountain ranges are block mountains. These mountains are usually rough and rocky and do not give much opportunity for man to live there, although they do hold a great storehouse of mineral wealth. Some mountains result from the surrounding country having been carried away by erosion, leaving the harder rock underneath exposed. Lookout Mountain in Tennessee is of this kind.

Science Service

An earth fissure on a fault line made in a recent earthquake in Utah.

Earthquakes. Deep in the earth, under great heat and pressure, rock masses may be bent and twisted as if they were plastic like putty. But in the outer shell of perhaps ten miles depth the rock is colder and brittle. As the changes which are essential to preserve equilibrium go on, these brittle layers of rock are put under severe strain and from time to time they crack or snap apart. Often long fissures develop and the rock on one side is displaced upward, downward, or to one side. These lines of weakness, once formed, become the source of frequent slipping

later on. All these movements result in earth vibrations of greater or less violence. These movements are known as earthquakes. No part of the United States escapes slight quakes. A little over a hundred years ago very severe earthquakes occurred in the lower Mississippi Valley. These may have resulted from strains caused by transferring so much material from the land to the gulf by the Mississippi River. In 1886 there was a severe earthquake which did great damage in Charleston, South Carolina. In recent years the greatest damage has been done along certain fault lines near the Pacific coast, which have resulted in the San Francisco, Santa Barbara, and Long Beach earthquakes.



This fence was connected before the San Francisco earthquake of 1906. How do you account for its changed location?

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

cold	uplift	surrounds	erosion
warm	elevation	doubt	earthquake
hot	nearby	sinking	coast
weathering	certainly	changes	ranges
lake	fault	make	mountain

That the interior of the earth is very (1)____ there is no (2)____. Changing pressures on the earth may result in (3)____ in one region and (4)____ in another. Our highest (5)____ (6)____ are parallel

to (7)____ lines. The slipping of one large mass of rock in the earth past another along a (8)____ line in the earth produces an (9)____. Mountains have resulted from (10)____ and by (11)____ of material which (12)____ them.

ESSAY TEST

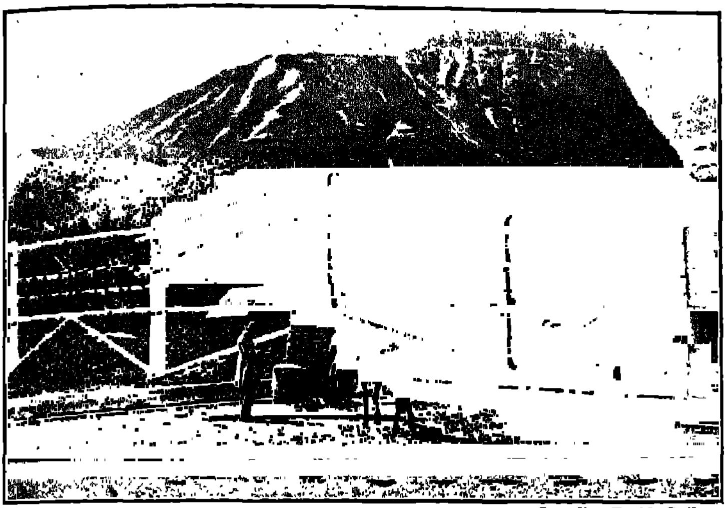
Lewis Gives the Modern Ideas of Mountain Making

Read carefully and critically. List all the errors and suggest corrections.

Formerly they likened the earth to a hot baked apple; the crust of the earth represented the skin of the apple. When a hot baked apple cools, the skin wrinkles. They made the comparison that as the earth cooled the interior got cooler, and as the crust tried to fit it, it caused mountain ranges. There are many reasons to believe this is the case. There are other reasons that can form mountains. Fill a rubber hot-water bottle full of water. Close it. If you now load one part of it with a small iron bar, that part sinks but some other part rises. If you press in with your fingers, you can see some other part fill out. The earth is full of material so hot that if it were not for the great pressure of the earth's crust upon it, it would be liquid. This is always under pressure. Piling up sand on the continental shelf increases the pressure on it. Removing the rocks from the land by erosion decreases the pressure there. The result is that by a lever action the continental shelf goes deeper and the land area rises to balance. If some part of the land is weaker than another, it may give way. When cracks occur, there will be an earthquake. If an opening is made deep enough, liquid rock will run out and a volcano will be formed.

PROBLEM II. WHAT PART HAS WATER PLAYED IN SHAPING OUR EARTH?

How Valleys Are Made. An airplane view of the country will disclose many heights of land which apparently divide the watershed, causing the water on one side of the highest point to flow into one river and that on the other side to flow into another river. Such a height of land is called a *divide*. A divide determines the direction of the flowing waters, and the resulting rivers have, through the long ages, cut and worn down



Canadian Pacific Railway

Water flows from one side of this divide into the Pacific Ocean and on the other into the Arctic Ocean. Do you see why it is called the Great Divide?

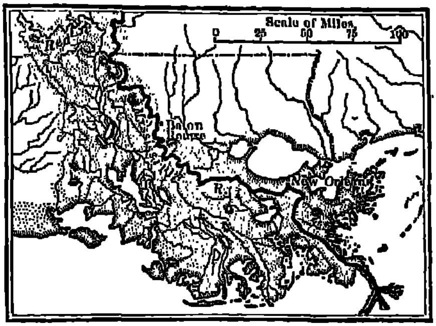
the rocks and land to form the valleys. The erosion by the river makes the valley deep; its winding back and forth and the weathering make the valley wide. In its early stages the river is deepening this valley rapidly, its sides are steep and often rough and rocky. The old rounded mountains of the Adirondacks and White Mountain ranges have been in a process of change for a long, long period. After the soil was formed and vegetation covered the hillsides, the work of changing went on more slowly. The deep notched canyons of the far west, however, which show the forces of recent erosion by water, are known as young valleys, and have been made in quite recent geological time.

How Deltas Are Made. Another result of erosion is seen in the formation of deltas, great triangular areas of earth at the mouths of large rivers. Deltas are formed entirely of material which has been carried long distances by rivers and finally deposited where the current of the

Asahel Curtis, Courtesy U. S. Forest Service

The upper picture shows an old valley in the eastern part of the United States. The lower a young valley in the Rocky Mountains. How would you sum up the characteristics of the mountains in each?

water is slower, usually at the mouth of the river. The glaciers which at one time covered all the northern part of the United States must have furnished an immense amount of water and billions of tons of soil to the rivers, which aided in the formation of some of our southern states. It is estimated that four hundred million tons of sediment are carried each year to the Gulf of Mexico by the Mississippi River, but the delta only grows at the rate of one sixth of a mile a year. This delta must be very deep, for a well sunk in New Orleans brought up a piece of driftwood from a depth of 1042 feet.



The delta of the Mississippi River. Can you *explain how it was formed?*

Flood Plains. At time of flood, rivers carry much sediment, and when they break through the banks and spread over the plains, the speed of the water is slowed up greatly, thus allowing much material to be deposited. This material forms soil. A large part of the soil of the earth has been moved by water. In this moving much of the clayey material which does not make good soil for crops by itself is mixed with sandy soil. The sand makes the clay more porous and forms loam, which is fertile and easily worked. These mixed soils are found on plains and lowlands, causing these regions to be of great value to agriculture.

Why Sediments Are Deposited in Layers. The swifter the water flows, the larger particles it can carry. Slowly moving water can carry only very fine particles. If rivers always had the same volume and moved with the same

speed over the same material, the deposits would be uniform. But our rivers vary greatly in volume and speed, and their carrying power increases tremendously with increase in speed. If a stream has speed enough to move a rock the size of a baseball, at double the speed it can move a rock equal to 64 baseballs. If we increase this to three times, its carrying power is increased 729 times. This fact accounts for the damage done by swift waters at the time of flood. Because of the varying volume and speed of rivers, the kind of sediment carried and deposited at one time will vary greatly, so that we will have layers of fine material alternating with layers of coarse material deposited on the flood plains.

© *Hileman*

What size particles do you think this stream would carry?

The Continental Shelf. A good deal of the sediment carried by rivers reaches the ocean. This fine sediment is moved by currents, so that a continuous deposit extends all along the edge of the continents. This makes a gently sloping underwater plain which reaches out from the shore to a distance from 50 to 100 miles. This plain, called the *continental shelf*, ends abruptly in the very deep waters of the ocean. The water is shallow over this area, for the most part being only a few hundred feet deep.

Effect of Salt on Deposition. Since rivers carry clay particles so much farther than they do coarser particles, it has sometimes been wondered why there are not greater clay deposits far out in the ocean beyond the continental shelf. A simple experiment will help to explain this.

Demonstration 1. Suspensions of Clay in Fresh and in Salt Water.

Fill two pint bottles $\frac{3}{4}$ full of water. In one dissolve a tablespoonful of salt. Put a teaspoonful of dry powdered clay into each bottle. Cork and shake both bottles. Place them in the window or in front of some bright light and watch them.

(1) In which one do the particles remain in suspension the longer?

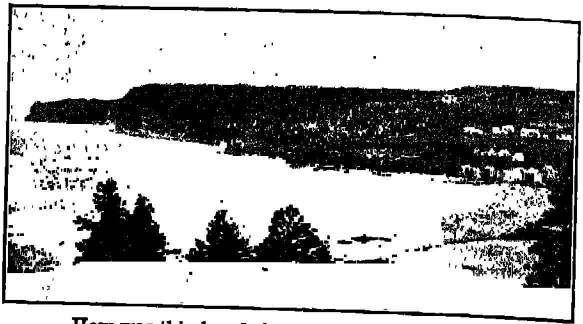
(2) What is the effect of the salt upon deposition of suspended matter?

(3) How does the suspension of clay particles differ in oceans from that in inland lakes and rivers?

From this experiment it is readily seen that clay cannot remain suspended in sea water long enough to be carried beyond the edge of the continental shelf. The deposits out in the deepest ocean are therefore derived from other sources as volcanic dust and remains of plant and animal forms that have lived in the ocean.

Ocean Action. Ocean currents along the shore depending upon their speed carry many fine to coarse rock particles. The waves in time of storms beat upon the shores with terrific violence. They may batter the rocky cliffs, causing them slowly to crumble. They may wash away the unprotected banks of soil. The long arm of land in Massachusetts known as Cape Cod, which is a deposit of glacial origin, is being worn away at a rate of over two feet a year at its narrowest point, and it is only a matter of time, variously estimated at from two to five thousand years, when it all will have been washed away. At the same time that the waves are wearing the land away in some places they are building it up in other places. Where the currents are slower because of protecting headlands or more shallow water, they may give up their

load of sediments. In this way many of our beaches with their marshy backgrounds are produced. The beaches in some places are mostly pebbles and in other places sand.



How was this beach formed? Read your text.

The size of particles deposited depends upon the principle of the sorting power of moving water. This picture shows how some beaches have been built in the New England area.

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

mountains	sentiment	steeper	particles
rocks	erosion	elevated	deltas
valleys	weathering	broad	carrying
hills	old	sediment	plains
slope	young	volume	speed
rivers	abrupt	continent	flood

River (1)____ removes weathered material and carves deep (2)____. A (3)____ valley has (4)____ sides than an old valley which is (5)____ and its sides are less (6)____. Deposits of (7)____ along the overflowed banks of a river form (8)____ (9)____, but near the river's mouth they form (10)____. A river may vary in (11)____ with the season. The greater the (12)____, the greater the (13)____, and because of this the greater the (14)____ power of a river. Larger (15)____ can be carried in time of (16)____.

ESSAY TEST

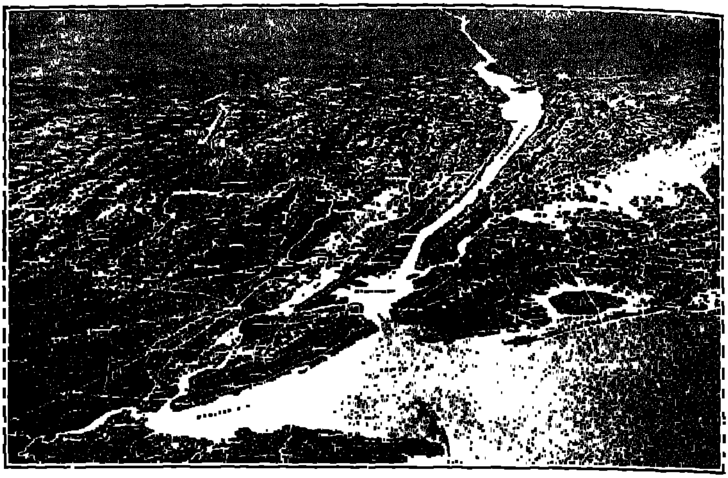
Marin Makes Science Observations on His Travels

Read carefully and critically. List all the errors and suggest corrections.

Last summer I went through the Canadian Rockies. At one place I saw a stream of water coming towards me divide, one part turning to the right and the rest to the left. I was told that one stream would run into the Pacific Ocean and the other into the Arctic Ocean. Can you give the technical term to apply to this height of land? I just wondered which would reach its ocean first, what work it would do on the way, and what each would contribute to the ocean it was going to join. Would any of the water fail to reach the ocean? I saw plenty of evidence of what other streams of water had done in making a similar journey. I saw muddy streams and clear streams and I knew right away that the clear streams had no fish in them. When fish move around, they stir up sediments and make the water muddy. While boating on a large river not far from the ocean, I remarked how clear the water was. My companion covered a wire hoop with cloth and let the water flow through that. My, but it was dirty when he took it out. There were quantities of fine gritty particles. If it were not for such particles carried year in and year out, there would not be much of a continental shelf along our coast.

PROBLEM III. HOW MAN HAS MADE USE OF LAND AND WATER SURFACES

Factors Which Have Resulted in Settling Our Country. We all know what a lot climate and water supplies have to do with man's activities. But few of us think very much about what the contour and geological formation of the land had to do with its settling and the later growth of cities. We know the Pilgrim Fathers thought the Massachusetts coast an inhospitable place after their first winter, and we know what struggles the Spanish Padres had to colonize the western coast. But in one case it was climate and in the other water supply that made colonizing difficult for these two groups on opposite shores of the country. And yet if we think a moment,



Air map of the great harbor of New York. Explain why New York is a favorable site for a city.

we can see reasons why different parts of our country were settled and grew. Along the eastern seaboard, towns sprang up at points where there were harbors. Settlers pushed westward along river valleys and settled where they found fertile flat or gently rolling land having water. The pushing on of the pioneers to the far west was partly adventure and partly a desire for more free land on which to hunt, trap, and make homes. Then the gold rush to California in '49 and the almost equally famous rush of miners to the Rockies, west of Denver, in the early '70's resulted in settlement, not so much of the wild, rocky regions where the gold was found but of the cities of San Francisco and Denver, which formed bases for supplies. If we look at a map of our country, we find that most of the larger cities are scattered along the coast at the mouths of rivers, or if not there, on rivers that are navigable. In the central west, with but few exceptions, the cities are near waterways. In the Rocky Mountains region the few large cities there have come

into existence because they were important railroad or supply centers for the surrounding country. A very large part of our more thickly populated country lies along river valleys or at points where water communication is easy from one place to another.

How Valleys Affect Man. A young valley does not make a very good place for man to live in, for the rivers are generally too swift for navigation, although they do produce water power. There is little opportunity for agriculture, but the mountain sides may provide timber. On the other hand, an older valley, with its gently sloping sides and its fertile floor, makes an excellent place for agriculture. Often such valleys have navigable rivers and so give opportunity for commerce. Cities will spring up there because communication is easy. Railroads usually follow rivers, and broad valleys like the Ohio are places favorable for man's activities. When the valley becomes very old, its sides widen out still more and large poorly drained plains that may be flooded in high water are formed. Such a valley is seen in the lower Mississippi region.

Courtesy U.

Valleys have come to be pathways of civilization. Wh

great plains exist only a few feet above the normal flow of water. He does this by means of building high retaining banks called levees, but the flood waters often break through these banks, causing great damage to crops and homes.

How Sediment Causes Trouble. Sediment carried in rivers makes trouble by elevating the river above the surrounding country. This was seen in the case of the Colorado River. In 1904 it began to change its course through an irrigation ditch, and by 1905 all the water of the Colorado was discharged by way of this opening into a great depression lying below its bed in southern California. Before long it formed the Salton Sea, about 45 miles long,

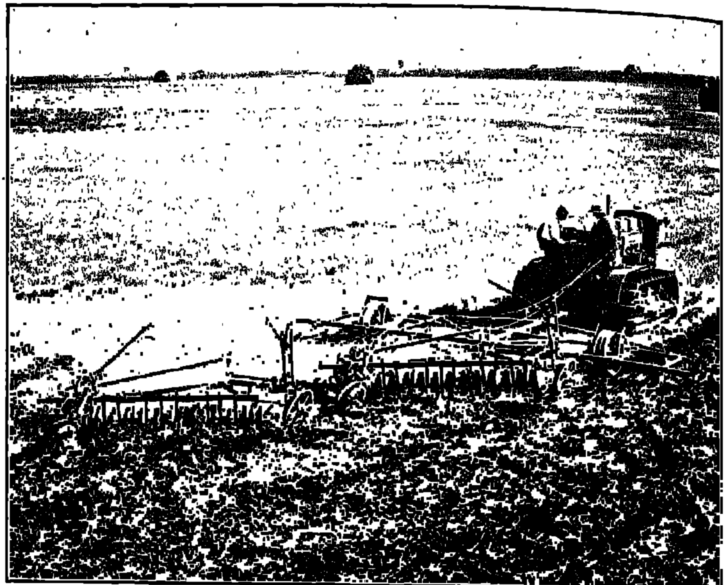
Wide World

Results of a broken levee on the Mississippi River. What can you find out about the 1927 flood? Have there been more recent floods in this region?

10 to 15 miles wide, with a maximum depth of 76 feet, and its waters were rapidly encroaching on the fertile Imperial Valley, just to the south. Only by hard work and the expenditure of millions of dollars was the gap closed and the river made to return to its old channel. The surface of the Yellow River in lower China flows in a groove at the top of a ridge, and when it goes into flood, it may either cover vast areas of land, or even, as it did in 1852, make a new channel for itself miles away from its former bed. This has resulted in famine and death for millions of Chinese. Flood waters carry more sediment, and as they slow down upon reaching more nearly flat areas they deposit a large part of their load. Often large rivers build up great deltas made of the sediment that they have deposited near their mouths such as seen just below New Orleans. Millions have been spent there to hold the Mississippi in its channel. New Orleans is largely below the water level and about the only hills are the artificial ones that go up to the river's edge.

Control of Floods. Such floods as have been described are usually due to the forests near the head waters of these rivers being cut away, leaving bare land from which rain water flows off quickly. In China these forests were almost completely cut away centuries ago, with the result that the country has constant recurrent floods. The best control of such conditions would be to reforest these areas and build controlling dams which would hold back the water and distribute it slowly.

Other Ways in Which Water Has Changed the Earth's Surface. During the age when glaciers covered the northern part of the United States, 20,000 to 50,000 years ago, there was a great lake covering over 110,000 square miles in the area now occupied by the region of the Red River of the North. This region, now drained, is an important wheat-producing area. Plains are geographically the most favorable areas for man because they give



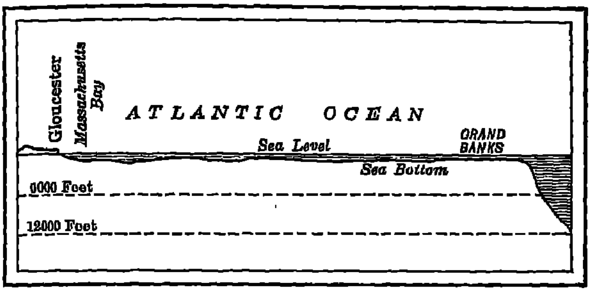
Anderson Photo

Farming in the Red River of the North area. This was once a big lake. When? Do you know why this lake dried up?

him much land for farms and easy transportation both by road and railroad.

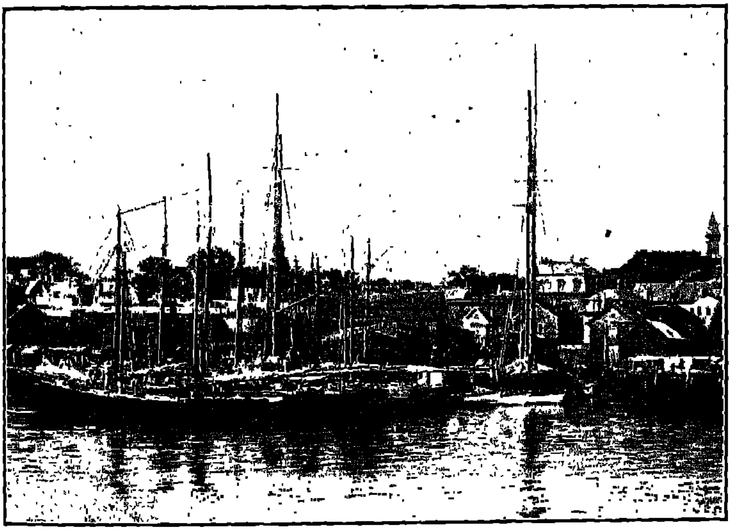
The Effect of the Continental Shelf on Man. In many parts of the world the coast is rising. When this happens, the continental shelf is slowly elevated and we have a coast like that seen in the Virginia and Carolina coastal areas, lowlands dotted with salt marshes. Such a coast, because it is sandy and has to be fertilized, is not being used for agriculture, and consequently will not be thickly populated. Where the coastal plain joins the older mountain areas, rivers usually cut down into the newer land to form waterfalls. The boundary between the old and newer land on such rivers is called the *fall line.* In former days when water power was very important for grinding grain and sawing lumber, and because it marked

the head of navigation, the fall line became the location for many small cities. You can find a series of such towns



The continental shelf off New England. What effect does this have on Gloucester, Massachusetts?

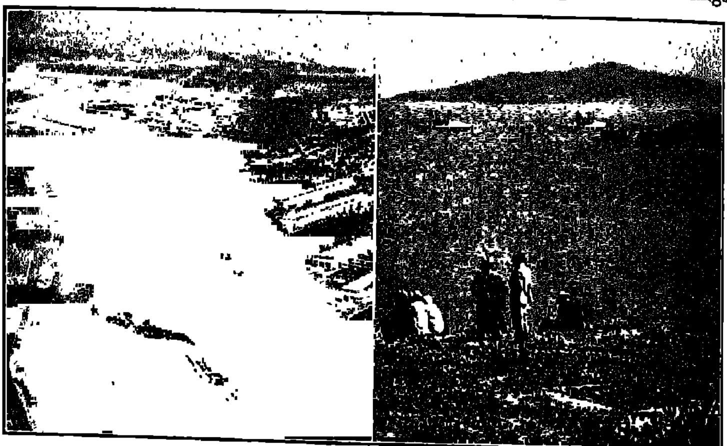
by studying geological maps of the region near the eastern seaboard. The continental shelf along the ocean coast provides relatively shallow water, which favors certain forms of life. Cities with large sheltered harbors near the fishing grounds may depend almost wholly upon a



Gloucester, Massachusetts, is the center of a great fishing industry. Give three reasons why this is so.

single industry, as does Gloucester, Massachusetts. The salt-water inlets up the James and Potomac and Chesapeake Bay offer many shallow areas well fitted for oyster farming, while the more rugged New England coast is better adapted for lobster fisheries.

The Effect of Sinking and Rising Coast Lines. In some places the coast is sinking instead of rising. In this case the sinking of the land makes an irregular coast line, with many good harbors, such as that of San Francisco, Boston, and New York. Such coasts are very favorable for settlement, and are most important factors in our commercial life. Sinking coast lines make deep harbors, but sometimes offer little flat land for a city. San Francisco and Seattle have good harbors but are very hilly. Los Angeles, where the coast line is rising, is more level and had no natural harbor. The water was so shallow that large ships had to anchor three miles out until an artificial harbor was made. This change of a shallow and unsafe anchorage area to a protected safe harbor with deep water shows how a progressive people can change



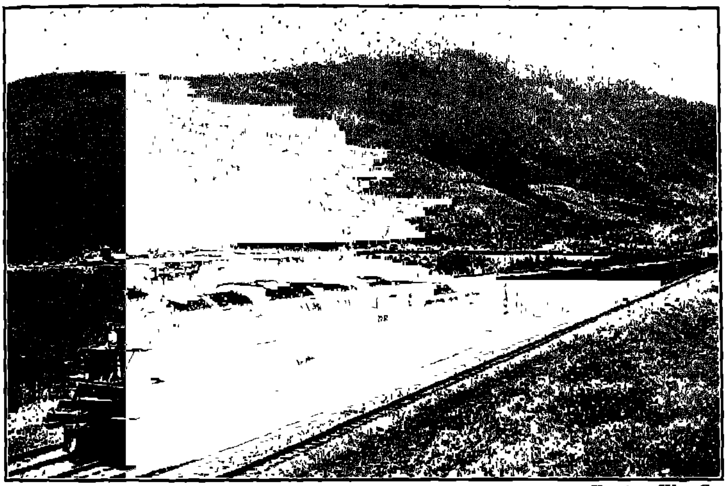
Californians, Inc. *Publishers' Photo Service*

Los Angeles has an artificial harbor. San Francisco harbor is a natural one. How would you account for the difference geologically?

their natural environment. The freight tonnage out of Los Angeles is today second only to that from New York.

Rising coast lines, such as we see along the eastern seacoast south of New York and in southern California, do not give us good harbors, but they may give large stretches of level land. Our long sandy beaches below Los Angeles, in New Jersey, and Florida make a playground for millions of people. Many types of recreation are found at the beaches that cannot be had at deep-water resorts.

How Mountains Affect Mankind. Mountains have few areas level enough for a large city. The soil does not



Keystone View Co.

Mountain barriers are now overcome by the engineer and powerful engines. What have you already learned about the inclined plane? Are other laws of machines illustrated here?

average as deep or as rich as that on the plains. Transportation is difficult; manufacturing is not favored; cattle raising, mining, and lumbering are industries that may be carried on there, but these are often only temporary. Mountain regions are usually backward, school

facilities are poor. Some mountain resorts, however, are successful in offering a healthful atmosphere, quiet for tired nerves, and fishing and hunting for those who enjoy these sports. We have seen that mountains are the sources of much of our water supply and our water power. They also have a great effect on rainfall. Young rugged mountains give very little opportunity for man to settle, as they are rough and have little good soil. But mountains give us forests, an important asset, and also contain much of our mineral wealth.

Great Northern Railway

The new eight-mile tunnel under the Cascade. This tunnel established a record for tunnel building and conquered a mountain barrier.

Mountains have always acted as barriers against settlement and have kept roads from being built and railroads from entering new territory. The Great Northern Railway recently built a tunnel eight miles long, costing $14,000,000, in order to save time in transportation between Spokane and Tacoma. In Europe the

Simplon tunnel, 12.4 miles in length, is still the longest railroad tunnel in the world. Mountain passes have always been an important factor in transportation. With few exceptions railroads still follow the lower passes, as did trails and roads before them.

The Uses of Plateaus. The great uplifted regions west of the Rockies are largely used for cattle and sheep grazing and ranching. In many parts of the country a semi-desert condition is found, but, thanks to the fact that large rivers flow through these regions, irrigation can be practiced and much waste land used. Such land makes an excellent place to grow fruit trees and various kinds of grains. In Central America the plateau region is very fertile and much of the wealth of agricultural products comes from these regions.

Plateaus are also storehouses of minerals, as can be seen if we look at a map of the Central plateau. Nevada, Utah, New Mexico, and Arizona have gained most of their wealth from this source.

SELF-TESTING EXERCISE

Select from the following list the words which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

minerals	forms	barriers	flood
valleys	sinking	deltas	ranching
stationary	rising	young	communication
settlement	grazing	water	floods
mineral	rapid	forests	navigable
old	mouths	heads	sailing vessels

Land (1)____ have had much to do with the (2)____ of this country. Large cities have come to occupy places at the (3)____ of (4)____ rivers on (5)____ coast lines. The population has followed (6)____ river (7)____ and has used rivers as routes of (8)____. Because of fertility, (9)____ plains and (10)____ have been thickly settled in spite of constant danger from (11)____. Mountains have formed (12)____ to civilization but are also the

source of much of our (13)____ wealth, of (14)____ power, and our (15)____. Plateaus also hold many (16)____ resources and have large areas devoted to (17)____ and (18)____.

ESSAY TEST

Tom Tells about His Trip West

Read carefully and critically. List all the errors and suggest corrections.

Last summer I had a most interesting trip west. It was made more interesting because I tied it up with my general science. In the first place I left New York which is at the mouth of a navigable river on a sinking coast region. These facts give New York its commercial importance. The railroad followed the Hudson and Mohawk rivers, both of which have formed natural pathways for Indians and white settlers. We passed through Cleveland, Detroit, and Chicago, all settled on large bodies of water. As we crossed Illinois and Iowa, we got into a region of flood plains and further on the prairie states represented a similar region. At Denver we got our first look at the Rocky Mountains. We went through the famous Moffett tunnel, which took us into the mineral-bearing region of the Rockies. The railroad crossed the continental divide at a great altitude and wound its way down, following old river valleys until we reached Salt Lake City. I went out to Saltair and had a swim in the Great Salt Lake. Afterwards we crossed part of it on a viaduct and went on our way over the deserts of Nevada and over the Sierras to San Francisco. As we followed the Truckee River through the mountains, I saw several men trout fishing and noticed the mountains were covered with big pines. It was a great trip, made more enjoyable through my knowledge of geology.

THE REVIEW SUMMARY

In preparing a summary of what you have found out in this unit, you will want to place emphasis on the big ideas which have come from the applications of the facts you have learned and the demonstrations you have seen. Doubtless you have done some additional reading which has helped you put together some of the facts into generalizations or fundamental underlying principles. For this unit some of these generalizations are:

1. The surface of the earth is constantly changing.
2. Some coasts are rising and some sinking.
3. Most mountains have been formed by readjustments of material over large areas.
4. Earthquakes are caused by slipping of blocks of surface rock along fault lines.
5. Young valleys are deep and have steep sides; old valleys are wide with rounded sides.
6. Rivers carry much sediment, forming deltas, flood plains, and continental shelves.
7. The contour of the land has had a large part in determining where man would make settlements.

Before making your review summary for your workbook, test your knowledge of the facts of the unit by checking over the text so as to be sure you know the facts underlying the science principles or generalizations. Then using this material and everything you have read, seen, or done yourself, make your summary outline. This outline you may use when you make a recitation.

TEST ON FUNDAMENTAL CONCEPTS

In a vertical column under the heading CORRECT *write the numbers of all the statements that you believe are true. In another column under* INCORRECT *write the numbers of the false statements. Your grade = right answers* $\times 3\frac{1}{3}$.

I. **River valleys are:** (1) made deeper by ice action; (2) broadened by weathering; (3) broadened by the river winding back and forth; (4) filled up by erosion; (5) too narrow to be of importance to man.

II. **The sediments carried by rivers:** (6) produce talus slopes; (7) make deltas; (8) build a continental shelf; (9) supply minerals held in solution by the oceans; (10) make sand bars that interfere with navigation.

III. **Floods in rivers:** (11) may result from melting snow or excessive rainfall; (12) raise the level of the ocean; (13) because of the greater volume of water carry less sediment; (14) deposit much rich soil when they overflow their banks; (15) are natural occurrences and so never harmful to man.

IV. **Mountain ranges are produced by:** (16) the shrinking crust on a cooled core of the earth; (17) change in altitude of the ground on one side of a fault line; (18) volcanic eruptions; (19) earthquakes; (20) uplifts and folding, the results of readjustment of material on the earth.

V. **Earthquakes:** (21) never occur in the New England states; (22) have never been known in any of the Central states; (23) occur where mountains are forming; (24) may occur in connection with volcanic action; (25) may result when one earth mass slips past another along some fault line.

VI. **The following physiographic features are of great value to man for the reasons given:** (26) river deltas because they divide the stream into many small ones; (27) the continental shelf because it makes the water shallower and much safer; (28) a sinking coast line because it helps tidal action; (29) high rugged mountains for government parks; (30) young narrow valleys because they will widen and exist for many years.

PRACTICAL PROBLEMS

1. Discuss this topic: Variation in the Volume of a River.
2. What two types of loads do rivers carry to the ocean? Discuss some of the conditions which determine these loads and tell what eventually becomes of them.
3. Can you think of any way by which a sluggish river may, after years of slow motion, again become a swiftly moving stream?

INTERESTING THINGS TO DO, READ ABOUT, OR SEE

1. Send to the U. S. Coast and Geodetic Survey, Washington, D. C., for price list of charts showing changes in the Mississippi delta for different periods of time. Invest a few dimes in maps and you can make an interesting study of river deposits.
2. Find out what a "river pirate" is. This is not a man who attacks boats and people on rivers, but a river that is called a pirate. Consult physical geographies.
3. Famous volcanoes in history.
4. How can they tell the origin of an earthquake?
5. The active volcanoes of the world today.
6. The earthquake belts.
7. Is there any possibility that Chicago will be below the level of the lake waters within perhaps 10,000 years?

SCIENCE FOR LEISURE TIME

1. Planning for a Cross Country Hike

Secure from the U. S. Geological Survey contour maps of the region. Learn how to read these. Become familiar with the symbols and try to visualize the elevations and other features before

you start. Plan a route to follow and see how near you can follow it.

2. A Mountain Book

Make a scrapbook of pictures and clippings about volcanoes and mountains.

3. A Scenic Tour of the United States

With the aid of road maps, travel folders, and tourist guides, plan a summer trip and show where there will be natural earth features of special interest to be seen.

SCIENCE CLUB ACTIVITIES

1. A Field Trip

Make a field trip to some mountain, river, or seashore and study evidences of natural activities now going on. Find out from someone who knows the natural history of the region how it came to be as you now see it.

2. A Motion-Picture Meeting

Plan in some way to secure from four to eight reels which show typical physiographic land forms and water views in various parts of the country.

3. A Book-Review Meeting

There are many interesting books on volcanoes, earthquakes, caves, floods, and other natural phenomena. Search your public libraries for these books. Have about four members prepare to give a digest of one of these books at a regular meeting.

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Soley, J. C., *Sources of Volcanic Energy.* Putnam Co., 1924.
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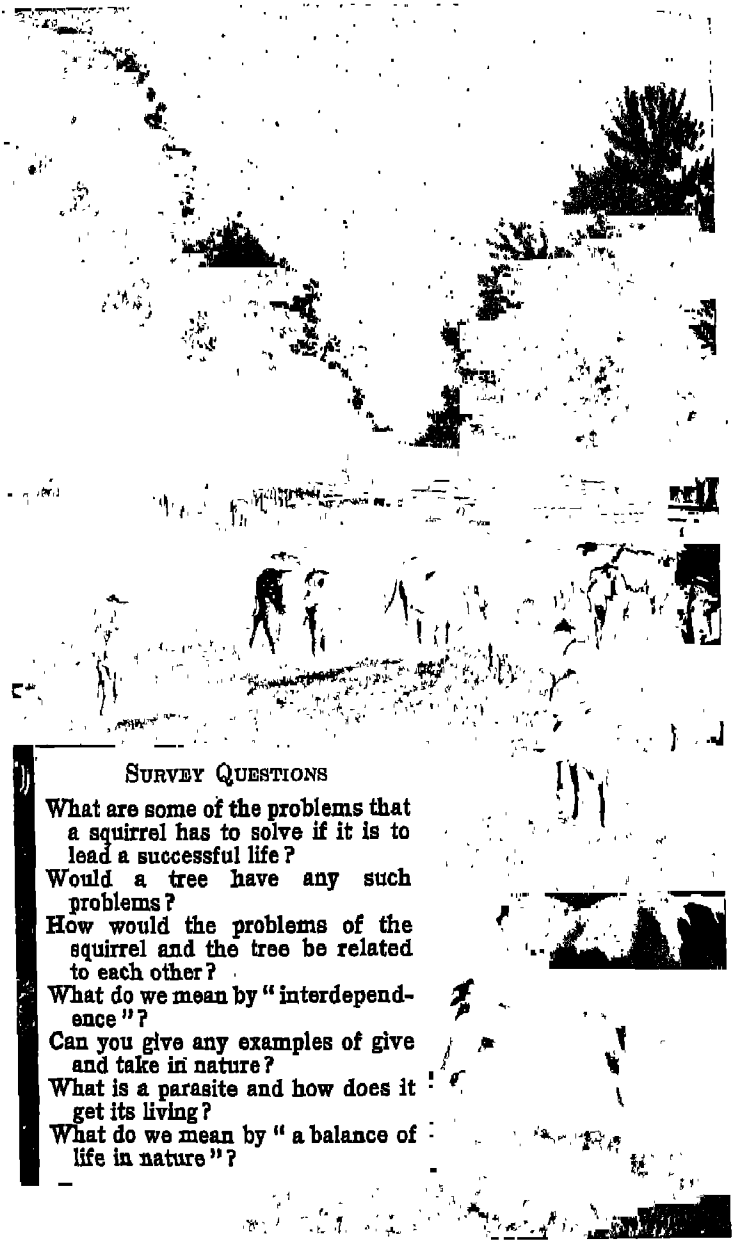


Survey Questions

What are some of the problems that a squirrel has to solve if it is to lead a successful life?

Would a tree have any such problems?

How would the problems of the squirrel and the tree be related to each other?

What do we mean by "interdependence"?

Can you give any examples of give and take in nature?

What is a parasite and how does it get its living?

What do we mean by "a balance of life in nature"?

UNIT XI

THE INTERDEPENDENCE OF LIVING THINGS

PREVIEW

You have all doubtless been for a hike which carried you off through the country to a dense forest. How good the shade feels after walking in the hot sun, and how quiet and peaceful the forest is! But it does not take long for you to discover that there is a good deal of life under those high arching trees. You see occasional birds or hear them twittering. You see insects and sometimes feel them. If you are fortunate, you may see a stray rabbit or squirrel, or even catch a glimpse of a larger animal, such as a deer or a fox. If there is a stream running through the woods, you will find fish in the pools, perhaps a turtle, along with frogs, toads, and possibly a water snake. If you look carefully, you will find under the water many insect larvae and some adult insects. Some are building curious tubes of little stones and sand cemented together, others are lying in wait for their prey in the sand and mud. Water striders skim over the water surface, and other insects are resting on the waterweed. And of course you cannot help but enjoy the trees, the thick shrubby growth, and the carpet of ferns and other shade-loving plants on the forest floor. What a good place for the animals to live in!

And yet if you were to study the lives of these animals carefully, you would find that not only were they living together, but they were also living on each other. There

is a web of interdependence, but it is also a cut-throat existence that is going on in the forest. Birds are living on insects, snakes eat the toads, turtles eat the fish, some of the insect larvae feed on others smaller than themselves.

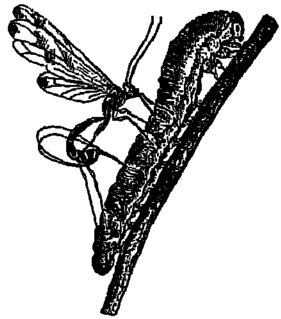
American Museum of Natural History

In the struggle for existence illustrated here find and name all the animals that prey on others.

A constant struggle is going on in which each animal and each plant as well has to fight for its place in the sun.

But these animals and plants are not all preying on each other. There is a give and take in the forest as well. Birds that eat the insects are helping protect the trees on which the insects feed. The trees give the birds shelter and a place for their nests. Among the insects, although

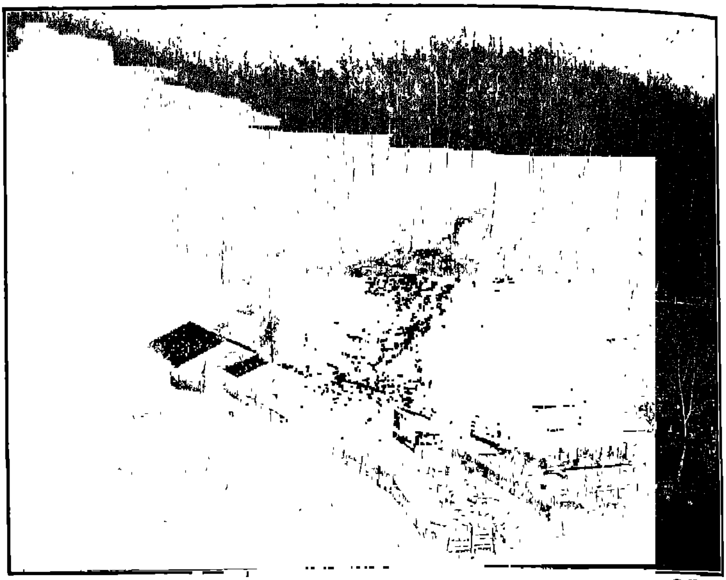
some may be harmful, others are useful. Watch that wasp-like fly and you may see it boring a hole into one of the trees. What is it doing? By some unerring instinct it will bore that hole into a burrow of a boring insect, find the young of the insect, and lay an egg in its body. This egg will develop into a parasite which will feed on the boring insect and kill it. Ichneumon flies may be seen laying their eggs in the body of some caterpillar which does harm. Spiders may be found catching caterpillars for their prey which feed in turn on the forest trees. You can find hundreds of other examples of mutual helpfulness among the plant and animal inhabitants of the forest which results in protection against harmful insects.



An ichneumon fly preparing to lay its eggs in a caterpillar. Are these flies useful or harmful? Why?

In this forest there seems to be a balance of life. One might suppose that the harmful insects would drive out all other forms and would populate the forest, for they and their progeny lay thousands of eggs in a season. But, somehow or other, largely because of the natural enemies that they have, relatively few of these insects go through the complete cycle of life. And so we find a balance of life existing. The ferns and mosses and other shade-loving plants, together with certain animals such as salamanders, toads, frogs, and snakes, are living in the areas of shade near the brook. Trees occupy a dominant place in the picture, but afford homes for birds, squirrels, and insects. But all live together and show a kind of balance of life.

But what would happen if man came into the forest and ruthlessly cut down the trees? You know that the



Galloway

Man is here interfering with the balance of nature. What may happen as a result of this?

balance would then be destroyed. The birds and other animals which lived in the trees would lose their homes and would either be killed or forced to go elsewhere. The cut branches of the trees might become the homes of parasitic fungi and bacteria which would gradually destroy them by causing them to rot. The undergrowth which demanded shade would soon disappear and other forms of life would take its place. Perhaps there would be a fire and then an entirely new growth would spring up over the area. Or the land might be cleared and made into a garden, and here again man would introduce new forms of life quite different from those which originally existed there. But even with man in control, there would be eventually a balance of life in that garden. Insects would come in to destroy it, but man would fight the insects. If drought threatened, man would water the

garden. He would hoe it to give air to the roots of the plants, and weed it to keep out these pests. In other words, an artificial balance would be maintained. This illustration gives us some idea of how life goes on in the world. It is give and take. It is struggle. And in the long run, in civilized countries, it is artificial, with man controlling the balance.

Before we go further, let us look back and see what science generalizations we can build on what we learned in our science last year. The most important ones were these:

Science Principles

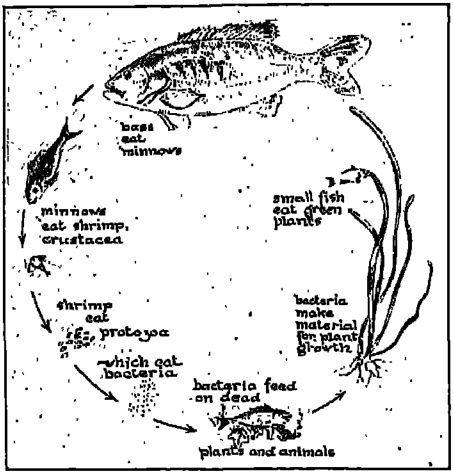
1. Living things respond to stimuli and adjust themselves to their surroundings.
2. The kind of living things found in a given place depends upon the environment.
3. Certain plants are always associated with certain animals in a given environment.
4. Green plants under certain conditions manufacture food for animals.
5. Living things can change food into living matter.
6. Living things come from other living things.

Use these facts as you study the pages which follow.

PROBLEM I. WHAT DO WE MEAN BY INTERDEPENDENCE?

The Web of Life. Someone has said that life is like a web; that living things are so entangled in their relations to one another that it would be hard to disentangle them without breaking the web down. There is a give-and-take relationship between living things all over the world, as we shall see from some of the examples that follow.

Interdependence in a Pond. You go fishing in your favorite pond and catch some perch or bass. These fish lived on smaller fish, on tiny water fleas or other crustaceans which in turn lived on animals and plants smaller than themselves, most of them single celled. But these one-celled animals lived on bacteria, life still smaller than they are. Here you might think we would come to an end, but the bacteria feed upon dead plant and animal matter, breaking this material down into substances that can be absorbed by green plants in the pond. These green plants in turn use water, the decayed material in the soil, and certain wastes from animals when they build up food in the sunlight. The green plants are used as food by insects and other small animals, which in turn are food for the fish. Thus a cycle of life exists in a pond which was rudely interrupted when you caught the perch.



How does this diagram illustrate the interdependence of plants and animals?

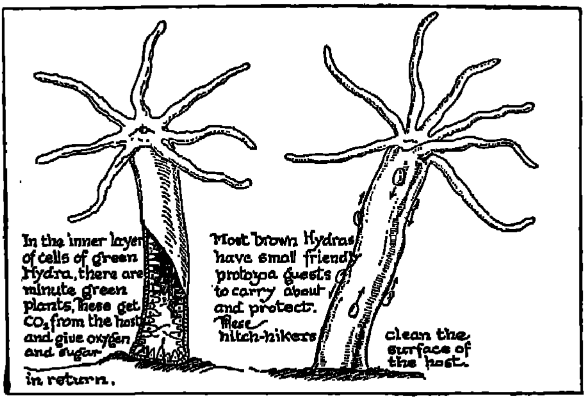
Interdependence in a Forest. We can see this same interdependence of life in the forest. Here larger animals prey upon smaller ones, the wildcat on rabbits or squirrels, or the wolf on the deer. But these animals that are preyed upon eat grass or green leaves and shoots of trees and bushes. Here again, were we to follow the interrelationship through, we would find that the green plant makes food from the wastes given off by the animals, plus other substances in the air and water.

Interdependence of Termites and One-Celled Messmates. Sometimes this interdependence is very much closer than appears in a pond or the forest. There is a group of insects called termites which live in communities in the tropics. Here they do an immense amount of damage by chewing up wood. No house is safe, nor books nor anything else that is made of wood fiber. These termites, however, have strange messmates living with them, tiny one-celled animals which live in their food tube. These tiny boarders help to digest the wood fiber chewed up by the termite so that the latter can use it as food. Of course, as they do this, they get some of the food in the process themselves. Experiments have been made in which these one-celled animals in the body of the termites have been killed while their host was left alive. This was done by heating the termites sufficiently to kill the one-celled animals, but not their hosts. These termites when put back in their homes were unable to use the wood which they chewed up. They soon died because they needed the tiny one-celled animals which lived in their food tubes. This illustration shows a still closer weave in the web of life, which we call *symbiosis*.

Life Is Also a Struggle. We must not think that everything is give and take. On the contrary, most

Ants and aphids. The ants are "milking" the aphids by stroking them with their antennae. Have you ever seen aphids? Where? What kind of a relationship does this show?

plants and animals are working very hard to hold the position they occupy in life and to get their share of the energy which comes from the sun or from the food they eat. If you think of it, you can see that all energy in the first place comes from the sun and that plants use this energy in order to build up food. Animals also use the sun's energy, for most of them require the sun's rays to keep well. But, nevertheless, the struggle for a place in which to live and for food to eat goes on. We even have the one-sided relationship known as parasitism in which it is all "take" and no "give." We have seen examples of this in the fungus which lives on and destroys plants, or the bacterial parasite which carries disease. We can find examples of plant and animal parasites all around us if we look for them, and each one of them is playing a part in this struggle for life on the earth.



The hydra is a little animal about the size of a pinhead when contracted. With its tentacles extended as shown here it is half an inch in length. It lives in fresh water ponds and feeds on small water animals. What kind of relationship is illustrated here?

Balances in Life. You may wonder why it is that one part of the world is not populated by one kind of animal or plant. We do see schools of fish, or ant colonies, or

fields of daisies, or colonies of bacteria, but other plants live in the field with the daisies and many other forms of life are found with the school of fish. All over the world living things seem to be pretty well scattered and no one form occupies a place without others sharing the locality with them. Animals and plants live together in places that they are best fitted to live in. There is usually a balance between living things in a plant or animal community. Sometimes introduced weeds crowd out plants in our garden, or we may have cases where man has almost destroyed some kind of animal. Such, for example, was the near extermination of the buffalo, which was slaughtered by the thousands for its skin and its tongue in the days when the West was being won. We might also wonder why some plants or animals have not completely driven out all others when we realize how rapidly they reproduce. Take, for example, the house fly which at the end of the season may be responsible for over a million other flies, or the mosquito which lays from 200 to 400 eggs at a time. Suppose that of these eggs half produced males and half females, and that each of the females laid another batch of eggs in 10 days after it became adult. If you repeat this with each generation, you will find at the end of the season that a single mosquito might give life to between 1,000,000 and 2,000,000 offspring. At the rate that mosquitoes breed if unchecked, they would soon

L. W. Brownell

A community in which daisies are the prominent form of life. What other plants might live in a field of daisies?

cover the earth to the exclusion of everything else. Many fish like the cod lay several million eggs and the female salmon lays over a million. Why is it that these animals do not fill the rivers with their offspring? If you were to witness the way in which the salmon eggs, after they are laid, are eaten by trout and other enemies, and if you were to see how many of the female salmon fail to reach the spawning grounds because of enemies and the natural barriers of rapids and waterfalls, you would not be surprised to learn that only a few, sometimes only one or two of the young, survive to become adults. And so it is with the insects or other rapid breeders. They have so many

Ewing Galloway

A catch of salmon on the west coast. What enemies other than man does the salmon have?

Courtesy U. S. Forest Service

Deer in the Kaibab National Forest, just north of the Grand Canyon. When their natural enemies were killed off, they multiplied rapidly, became too abundant for their food supply and then died in large numbers from starvation. How would you suggest maintaining a balance in this area where there is little natural food for deer?

enemies, parasites which feed on their eggs or on the young, birds which catch them by the thousands, man with his many methods of destruction, that it is little wonder that few survive to continue the struggle as adults.

How the Balance Is Maintained. Life is, indeed, a struggle. Charles Darwin found that there were 257 seeds developed in a little plot of ground 2 by 3 feet. William Beebe has made similar observations in jungle territory. But a very small number of these seeds develop because they are crowded out or smothered to death by their neighbors. In the same way natural enemies eat the eggs of the cod by the millions. Other natural enemies, fortunately for us, like dragon flies and birds,

kill off the flies and mosquitoes by the thousands. The young of some animals die from lack of food because their parents have been killed, or the climate may be unfavorable for them, or they may have been overcome by their many enemies. Seeds produced in great numbers are eaten by birds or washed into unfavorable places, or are destroyed by insects. They may dry up, get too much water, or freeze in a severe winter. In other words, life is hard, and one form, feeding on another or growing more rapidly, may crowd out its neighbor, and thus bring about a sort of balance of life in which only the stronger and those better fitted for life in that locality survive.

Read your text carefully and then explain the diagram, beginning with the clover.

Man Sometimes Changes the Balance of Life. There is a much-told story of Darwin and his old friend, Huxley, which is worth retelling here. Darwin, in pointing out this interdependence of life, said that the amount of clover in England depended upon the number of cats there were. He explained this by saying that clover only produces seeds when bumble bees pollinate it. These bumble bees make their homes in the ground, in nests that are often destroyed by field mice. The number of field mice, of course, is kept down by animals such as the cat which prey upon them. Huxley went his old friend one better and said that another link in the chain were old maids who kept cats. This is only one example where man has brought about a control that either makes or destroys

the balance of life. His care of gardens, his love of fishing or hunting for sport, his use of fish or birds for food, all are examples of how he changes the balance of life. See if you can make up a chain of interdependence for some plants and animals that you know of, and then show how man has come in to change the balance.

SELF-TESTING EXERCISE

Select from the following list the words which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

existence	fish	dependence	celled
food	death	struggle	give
bacteria	man	interdependence	plants
frogs	green	pollywogs	helpfulness
drink	crustaceans	larger	living

Life shows many instances of (1)____ of organisms. An example is seen in a pond where large (2)____ eat smaller ones and these live in turn on smaller (3)____ or other tiny animals or (4)____. These small creatures live on one (5)____ plants and animals which live on (6)____. Here we would think we came to the end, but no. The (7)____ help (8)____ water plants by giving them materials which enable them to build up (9)____ matter. The water plants furnish (10)____ for small animals in the pond and they in turn make food for the (11)____ animals. Thus the web of life is held together by (12)____ of organisms. But life is not all (13)____ and take. It is a (14)____ for existence. This (15)____ results in a balance existing in life which is often ended by (16)____.

ESSAY TEST

Harry Tells What Is Meant by a Struggle for Existence

Read carefully and critically. List all the errors and suggest corrections.

Anyone would think that most animals had a pretty easy time in life, but really they don't have it so easy. Take, for example, the salmon. They come in from the ocean to lay their eggs far up in the cool mountain streams. To get there, they have to fight their way up rapids, jump waterfalls, escape the nets of man and the spears of Indians, until they reach the water where they lay their eggs. Here at last they are safe and the eggs are laid and protected by the mother fish until they are grown up. Of course the

young fish have a pretty soft time of it, for the mother hunts food for them and keeps them within the nest which she builds. Since there are only a few eggs laid, this is quite easy. When they are partly grown and almost able to take care of themselves, the mother fish guides them back down the river to the ocean. But here the struggle begins again, for bigger fish eat them, birds kill them, and man again nets them, so by the time they are adults, most of the young have been killed off. This illustrates the struggle for existence.

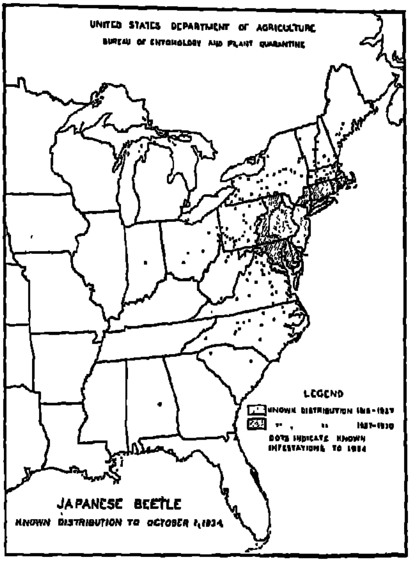
PROBLEM II. HOW THE BALANCE OF NATURE MAY BE UPSET AND RESTORED

Man May Upset the Balance of Nature. When man came to change life on the earth, he made his changes largely because he wanted to get more foods both for his present and future use. Primitive man probably used only such foods as he needed from day to day and depended, like other animals, on what he killed rather than on what he raised. The North American Indian killed only what he needed. He was never a fish or game hog like

Brown Bros.

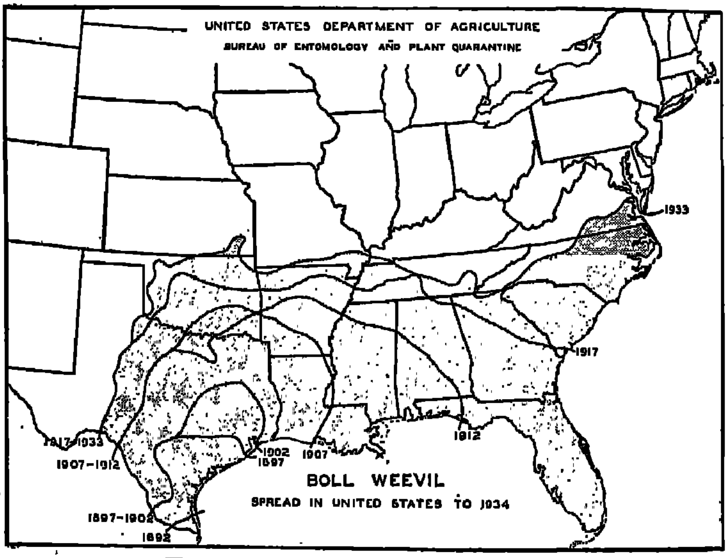
A rabbit drive in Idaho. Jack rabbits do much harm to vegetation in many parts of the West. But they do more harm in Australia because they have no natural enemies.

some men who call themselves sportsmen today. In this getting and storing of food, man upsets nature's balance. He may upset it by thoughtlessly introducing animals or plants into new areas where there are no natural enemies. Such was the introduction into Australia of the native rabbits from England by the homesick Englishman. These multiplied very rapidly, having no natural enemies, and now cost the government of Australia millions of dollars every year in an attempt to get rid of them. And it was another Englishman who planted water cress in one of the Australian rivers so that he might have some of his favorite delicacy, with the result that today water cress, having no natural enemies there, has actually clogged up some of the rivers, making navigation impossible. In making room for more food plants, man has destroyed the forest and native plants, and with them the wild life that lived there. He destroyed birds that prey upon insects, and straightway he had a plague of insects to contend with because he destroyed their natural enemies. Or he may introduce pests when he brings in new fruits or grains or vegetables, or carries on commerce with a foreign country; for example, the Japanese beetle was introduced into New Jersey in 1916 on the roots of some



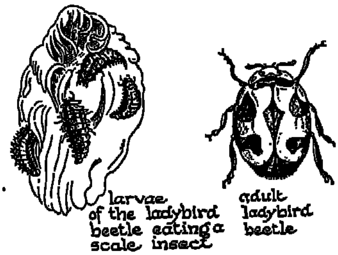
How do you account for the rapid spread of the Japanese beetle.

nursery stock imported with soil around their roots. In that year an attempt was made to destroy these beetles, but only 12 were found in that locality. In 1919 as many as 20,000 were caught in a single day, and today they have spread over all the eastern states. The Mediterranean fruit fly was introduced in the spring of 1929 into Florida, probably on some fruit which was brought in from Europe. This pest lives not only on fruits, but on vegetables and garden produce of all kinds, so that it could become a very serious enemy to man. Two years after its introduction, this fly had overrun 34 per cent of the land in Florida. Something drastic had to be done. The United States government voted large sums of money, put a quarantine about southern Florida to prevent any of the flies from getting out, and fortunately succeeded in exterminating them. But man has not been so fortunate with the pest known as the cotton-boll weevil, for this insect came over from Mexico in 1890 and has over-



How would you suggest combating this pest?

run the cotton-raising area in the United States. So far nothing has been found to combat it effectively. Everywhere the story is the same. Introduced pests are eating shade trees, destroying our fruits and vegetables, and generally disturbing the balance which man in the first place disturbed.



How is the ladybird beetle useful?

How the Balance Is Restored. All plants and animals have natural enemies which under most conditions keep them under control. In California a few years ago the cottony cushion scale, one of the many insects which feed on citrus fruits, was introduced into California. Orange growers were giving up in despair, for they could find no way to battle this enemy. But an insect collector from the United States Department of Agriculture, working in Australia, noticed that while there were some groves infested with this scale, it did not do very much damage. On further investigation he found a small ladybird beetle feeding on the scale. This beetle was introduced into California, multiplied very rapidly in its new home, and in a few months completely restored the balance of life by eating up most of the scale insects. This story has been repeated a good many times in late years. The government is sending out men all over the world to find parasites or enemies of introduced pests or plant enemies. We can spray, or kill, or burn, or try our best all the ways we know of to control insect pests, but the most effective way is to find some natural enemies, introduce them, and let them do the rest.

Spread of Plant Pests. But it is not insects alone that have come to make trouble for man. As he introduced

new grains or fruits, he also introduced new weeds. In the West, the Russian thistle, introduced only a few years ago, has come to be a great pest and has spread to all parts of the country. Many different kinds of parasitic fungi, rusts, and scales, many of which live on our food plants, have been introduced in a similar way. The railroads that first crossed the prairies were literally bordered by new weeds and seeds, which were distributed with the cargo carried by the freight trains. Man may often carry weed seeds on his clothing or domestic animals may carry seeds on their coats.

Insects Man's Greatest Competitors. It is said that insects eat enough every year almost to balance the budget, even in a depression season. Certain it is that man has to fight hard for every bit of new food he grows, and insects take at least a tenth of his harvest every year, and it is a constant battle. Man upset the balance of nature when he planted gardens and made clearings, and generally disturbed the condition of the land, so now he is forced to keep a balance in his artificial environment by means of controls of his own. These are (1) poisons which insects eat as they chew plants, or body poisons which are sprayed on the insects, thus killing them. Then (2) he may introduce parasites which feed upon these insect enemies, such as, for example, the fungi which are spread to grasshoppers through their food, or a worm which has been found to feed on the Japanese beetle; (3) he may introduce natural enemies such as the ladybird beetle; or (4) he may spend much time and money in destroying the breeding places of insects, thus preventing new broods the following year; or (5) the most important thing, he will protect birds, especially those which feed upon insects and weed seeds. Through these means of biological control of his environment are his best chances of fighting harmful insects.

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. The same word may be used more than once.

continue	keep	new	parasite
parasites	June-bug	upset	changes
destructive	beetle	useful	caterpillar
damage	pest	balance	life
usefulness	living	country	cat
old	fly	bug	citrus

Man may (1)____ the (2)____ of life on the earth, particularly when he (3)____ it by making gardens or planting crops. The (4)____ is destroyed because he brings in (5)____ forms of life, some of which may be (6)____ to the (7)____ things there. He may introduce by mistake (8)____ insects like the Japanese (9)____, which is now doing great (10)____ in this country. In most cases a (11)____ of (12)____ can only be reached by finding some (13)____ which feeds upon the destructive imported pest. Such (14)____ are usually found in the (15)____ from which the (16)____ was imported.

ESSAY TEST

FLORENCE TELLS WHY INSECTS ARE MAN'S GREATEST COMPETITORS

Read carefully and critically. List all the errors and suggest corrections.

It is said that there are more different kinds of insects than all the rest of the animals in the world, including man. That doesn't seem possible, but since it was in the Encyclopedia, I think it is so. But why are there so many insects? In the first place, they can all fly and so get around quickly. Then, many insects can eat any kind of food and that helps them. Then, they all lay millions of eggs and most of the eggs hatch. Man kindly comes along and plants food for them or introduces new destructive insects from other countries to feed on the plants he is trying to raise. If you have ever looked closely at an insect, you would find it protected by armor, which of course helps it. Then many insects are very small and can escape from their enemies. Insects haven't any natural enemies except man, so naturally they can compete with him.

Davey Tree Expert Co.

The same house before and after tree planting. What are the values of trees in the home grounds?

PROBLEM III. HOW DOES A GARDEN ILLUSTRATE INTERDEPENDENCE AND CONTROL?

Anyone who has compared a new house in a bare lot with a home surrounded by trees, shrubs, and gardens will see the value of living plants around the home. Climbing roses and vines give privacy to the porch, the trees give shade and make seats placed on the lawn enjoyable, the flower gardens give beauty and provide flowers for the house, while the vegetable garden may be made a source of profit if one gives time and thought to its care.

Examples of Interdependence among the Inhabitants of the Yard. No home is complete without trees. They are useful as well as ornamental. They serve to break strong winds in winter and give shade in summer. They also give off much moisture through their leaves. An oak may send off 260 times its own weight in moisture in a year. This moisture helps to cool the air and makes for a more uniform temperature.

But trees show interdependence between living things in many ways. Trees are the homes of birds which help the tree by freeing it from its insect enemies, like beetles which bore under the bark, like caterpillars which eat its leaves, or like beetle larvae which suck vitality from its roots. Earthworms plow the soil around the roots, thus helping the tree. Moles and gophers may eat the roots and harm it. Then man comes into the picture by watering the tree, digging up the moles and gophers, and killing the insects. His home gives off its sewage through drains, and these drains are often clogged by the roots of the trees, which absorb the wastes in the sewage. His fires give off carbon dioxide into the air, which the trees use in making food.

Interdependence in the Garden. Certainly we have many examples of interdependence in the garden. Flower

and vegetable gardens both show artificial conditions because they have been planted by man and because control is exercised by him from the time he plants seeds until he pulls up the beets and carrots and picks his peas. But still there are many examples of interdependence shown. Lawns are much improved by the addition of flower beds, trees, and masses of shrubbery, which should be planted for mass effect rather than to show off the separate plants. Flowers should be planted in front of the shrubs, and all of these should be used to cover fences, walls, and unsightly parts of the garage. One of the most attractive types of flower garden is one where old-fashioned flowers like phlox, larkspur, candytuft, pansies, delphinium, and hollyhocks are planted with tulips, violets, and narcissus for spring, and zinnias and chrysanthemums for the fall. Of course, you will want sweet peas, nasturtiums, and roses of various sorts.

Galloway

This is an old-fashioned garden planted with annuals and perennials. Do you know what these words mean?

But you ask, where does the interdependence come in? In answer let us watch a flower garden on a hot summer's day. Bees swarm there in myriads, and if we watch them, we will see that they are passing from flower to flower, evidently taking the sweet nectar from inside the flowers and sometimes gathering pollen to take back to the hives. But in so doing, you will also see that they spread pollen from the stamen of one flower to the pistil of another of the same kind. Bees in this way cross-pollinate the flowers and insure fruit for the coming year. Our crops of peas and beans in the garden, our apples, plums, and cherries, and almost all our seeds are dependent upon this process. If you were to dig up some of these pea or bean plants, you would doubtless find the little nodules on the roots which hold the useful bacteria which fix nitrogen, thus enriching the soil. But if you could go into the ground around the roots of the plants, you would find other useful agents at work: earthworms plowing the ground and useful bacteria giving a helping hand to the plants living in the garden. On the other hand, there are many enemies at work. A host of insects are getting their living from our plants, sucking and chewing stems, roots, and leaves, stealing the nectar and pollen, eating the seeds and fruits, and giving nothing in return. There are aphids on the roses and ants which are tending them. Watch them carefully and see if you can see ants "milking

Can you add any useful or harmful animals to this list?

their cows." Maybe there is a toad under the rose bush which kills cutworms and other harmful insects. Snails and slugs are feeding on tender shoots and roots; rabbits occasionally raid the lettuce patch and moles and gophers feed on the roots of the plants. The web of life is closely spun, even in this artificial environment, until man comes in with his sprays and poisons to kill the insects, or sets traps for the four-legged pests. Man is in final control. He fertilizes the ground; he puts in the plants; he even raises them in hot beds and cold frames. By means of the hot bed he can start plants in the winter or early spring and thus get ahead of some of the insect enemies, while the cold frame gives protection against the cold to some of the plants, such as tomatoes and melons, which would not stand the cold spring weather. He sprays poisons on insects, puts in bird baths and bird houses to attract birds, and he may even import a toad or two. But in spite of his control, the web of life is still closely spun, and the give and take in the plant and animal world still goes on.

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. The same word may be used more than once.

wastes	dead	burrowing	interdependence
man	insects	natural	dryness
moisture	harm	monoxide	dioxide
water	harmful	birds	earthworms
food	artificial	benefit	environment
living	carbon	uses	toads

Our home grounds or our garden illustrates (1)____ of (2)____ things there as well as the conditions brought about by (3)____ control of the (4)____ by man. A tree furnishes a home for useful (5)____, food for harmful (6)____, and shade for (7)____ himself. It gets aid from (8)____, which help to rid it of (9)____ insects.

Its roots are used as (10)____ by (11)____ insects and mammals, and are helped by (12)____ which plow the soil around the roots. Its roots often reach out to sources of (13)____, from drains which man has built. It uses the (14)____ from man such as (15)____ (16)____ and human wastes in sewage. It furnishes shade, (17)____ to the air, and the gas oxygen, all of which man (18)____.

ESSAY TEST

Etta Shows How Man Controls His Home Environment

Read carefully and critically. List all the errors and suggest corrections.

If you have ever compared a vacant lot with a similar lot which had a home on it surrounded by trees, shrubs, and flowers, you would surely say that man had complete control over his home environment. Especially would this be true if you compared a place which the people had neglected all summer with one that was well kept. How is this control maintained? In the first place, man has made the environment around the house. He has added rich soil, watered the plants, and added new factors in the environment. He has brought in new forms of life, not one native plant or animal is allowed to exist there. Not only has he planted new flowers, trees, and shrubs, but he has also introduced new insects or parasitic plants along with these. No wonder that he does not allow pests of any kind to come. He can prevent all losses by weather, insects, or plant parasites. Man is certainly in complete control of his home environment.

THE REVIEW SUMMARY

In preparing a summary of what you have found out in this unit, you will want to place emphasis on the big ideas which have come from the applications of the facts you have learned and the demonstrations you have seen. Doubtless you have done some additional reading which has helped you put together some of the facts into generalizations or fundamental underlying principles. For this unit some of these generalizations are:

1. Living things depend upon each other.
2. Living things are engaged in a struggle for existence.

3. There is a balance in nature.
4. Man may upset the balance in nature.
5. Man exerts control over his environment which results in making a new balance.

Before making your review summary for your workbook, test your knowledge of the facts of the unit by checking over the text so as to be sure you know the facts underlying the science principles or generalizations. Then, using this material and everything you have read, seen, or done yourself, make your summary outline. This outline you may use when you make a recitation.

TEST ON FUNDAMENTAL CONCEPTS

In a vertical column under the heading CORRECT *write numbers of all statements you believe are true. In another column under* INCORRECT *write numbers of the false statements. Your grade = right answers* × 3⅓.

I. **Life on the earth is like a web because:** (1) plants and animals are so dependent on each other; (2) spiders build webs; (3) if you destroy one member of a community, you are likely to change the lives of other members of the community; (4) there are food chains of animals, each larger one living on a smaller one.

II. **Symbiosis is illustrated by:** (5) an earthworm living in the ground; (6) a protozoan living in the food tube of a termite; (7) a tramp getting a handout; (8) a trout feeding on flies.

III. **Parasitism is illustrated by:** (9) a tapeworm in the food tube of man; (10) a fly in a manure heap; (11) a ladybird beetle feeding on a scale insect; (12) a caterpillar living in a cabbage plant.

IV. **A kind of give and take in life is seen:** (13) when a green plant makes food out of waste products given off by animals; (14) when one member of a family helps to support the others, and receives his room and board in return; (15) in a pond where the animals give off wastes which are used by the green plants in making food; (16) when the protozoans in the food tube of a termite help it to digest its food.

V. **A struggle for existence among living things:** (17) results in a balance of life on the earth; (18) means that living things succeed only at the expense of other living things; (19) is seen as well as mutual helpfulness; (20) results in the early death of all animals and plants.

VI. **Balances in life are maintained:** (21) by fish that lay many eggs, eating their own young; (22) because only a few forms can

survive in an area because of overcrowding; (23) because the natural enemies kill off the young about as fast as they are reproduced; (24) because each form has its own parasites which kill them off.

VII. **Man interferes with the balance in nature:** (25) when he cuts down a forest; (26) when he goes fishing; (27) when he eats dinner; (28) when he makes a garden.

VIII. **Man shows his control of the balance of life when:** (29) he purchases a watch dog; (30) he introduces the ladybird beetle into a citrus grove infested with scale.

PRACTICAL PROBLEMS

1. A tiger which leaves its jungle home to prey on the cattle of a neighboring village kills an average of a cow every week. Is it a parasite? Look up the term in the encyclopedia or in a good biology or unabridged dictionary.
2. Would the fish which lives in the school aquarium, if feeding on artificial fish food, be considered a parasite?
3. Would you consider the protozoans that live in the food tube of the termites parasites?
4. Give an example in your own community where man has upset the balance of nature.
5. Is there such a thing as social parasitism? Give an example.
6. Look up in a good biology and see if you can distinguish between the terms parasite, partial parasite, symbiont, and messmate or commensal.
7. How may your pet cat disturb the balance of nature in your yard?

INTERESTING THINGS TO DO, READ ABOUT, OR SEE

1. Make observations on aphids (little green plant lice) which live on rose bushes and see if you can find evidence of ants using them as "cows." See how the ant gets honey dew from the aphids.
2. Make a list of all the examples of mutual helpfulness between living things that you can find in an afternoon walk into the country.
3. Make a collection of pictures for the bulletin board to illustrate parasitism.
4. Make a collection of pictures for the bulletin board to sho[illegible] messmates.
5. Find some specific case of interdependence between li[illegible] things and try to show just what each of the partners does for [illegible] other.

6. Make a chart which will illustrate the "web of life" as it is found in a stream or pond.

7. Plan, plant, and care for a window garden.

8. Make a collection of the different native plants growing in your neighborhood which can be used in an exhibition plot in the school grounds. Remember such a collection must have the same conditions of shade, moisture, soil, etc., as does the original plant.

9. Read such a book as Beebe's *Nonsuch, Land of Water* and report on the struggle for existence under the sea.

SCIENCE FOR LEISURE TIME

1. Score your own home grounds or those of some neighbor with the following card, and make suggestions for improvement.

SCORE CARD. MY HOME GROUND

	Score: Perfect Score	Score: My Score
Grounds planned for beauty or utility	5	
Shade trees grouped	5	
At least one fruit tree	5	
Porch screened with climbing vines	5	
Well-arranged flower beds	5	
Flowers from spring until fall	5	
Flowering and ornamental shrubs	5	
Outhouses and garden screened with trees and shrubs	5	
Lawn attractive and well kept. Borders kept trimmed	5	
Play space with at least one game in use . . .	5	
Total	50	

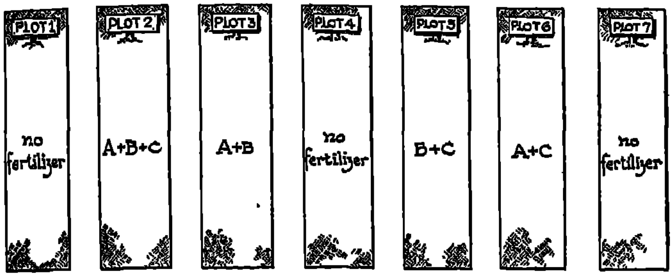
2. Make a bird bath for your yard out of an old galvanized iron cover of a garbage pail. Sink it level with the ground and plant iris and moisture-loving plants around it. Keep track of the visitors. You may have to put up a protective wire screen to keep cats out of it.

3. Try out the following experiment:

To learn what the soil needs for any particular crop.

(*a*) Does it need humus? (*b*) Does it need draining? (*c*) Does it need lime? (*d*) What are the three principal chemicals found in commercial fertilizers? Which are needed in my garden?

Suggestion. A test to show what chemical elements are most needed is best carried out in plot testing as follows:



A = 1 lb Sodium nitrate B = 1 lb Potassium sulphate C = 2 lbs Acid phosphate

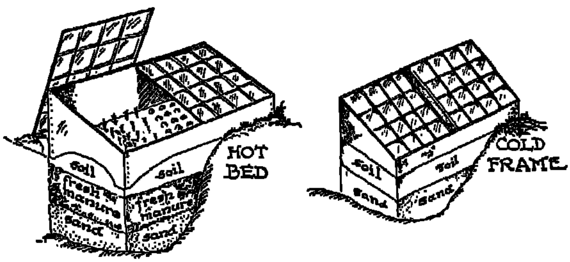
Make seven equal-sized plots, say 5 feet wide by 25 feet long.

A — 1 lb. Sodium Nitrate
B — 1 lb. Potassium Sulphate
C — 2 lb. Acid Phosphate

On plots 1, 4, and 7, use no fertilizer whatever; on plot 2 use A, B, C; on 3 use A and B; on 5 use B and C; on 6 use A and C. Plant same amount of seeds on each plot; give all the same care. Compare crops from each plot to decide the fertilizer most needed by the soil for that particular crop.

SCIENCE CLUB ACTIVITIES

1. Build a cold frame on the south side of the school grounds and plan for a supply of plants out of season for the classroom window boxes.



2. Plan and build a hot frame. Find out what plants for winter use in the school can be best grown in it. Organize a group who

will take on the work of supplying plants and seedlings for use in the school laboratories.

3. Have an exhibition of plants raised in hot and cold frames.

4. Make a survey of the school grounds to see where improvements in planting can take place.

5. Organize a soil survey of some part of your environment and make a collection of different kinds of plants and animals found in the different soil areas. Plot the results of the survey on a large chart and have it exhibited during some class period.

6. Plan a terrarium for the schoolroom and stock it with native forms of life. The terrarium can be made out of a large frame to which you tack a good quality of netting. Have the bottom of the terrarium made of a shallow galvanized tray or, if you cannot get this, use heavy boards and set in a shallow pan such as can be bought at the five and ten cent store. Fill the bottom of the terrarium with rich earth, if possible brought in with plants from the woods. Pack the space around the pan with growing moss. Put in some rocks and a few clumps of grass or weeds. Collect and plant in the box as many inhabitants of your nearby pond, woods, and fields as you can get, as well as toads, frogs, turtles, snakes, salamanders, snails, slugs, and large insects. The balance of life will not always remain the same, for there will be a struggle for existence in the terrarium.

7. Have a prize offered for the best window box and plan an exhibition to which parents and friends of the group exhibiting will be invited.

A prize window exhibit. Can you do as well?

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SURVEY QUESTIONS

You have heard about germs. Do you know what they really are?
Where would you find germs?
Do you know how people "catch" them for purposes of cultivation?
Have you ever thought of what the world would be like without bacteria?
Do you know in what processes bacteria are used?
List all the diseases that you know are caused by bacteria.

P. & A. Photo

UNIT XII

BACTERIA — GOOD AND BAD

PREVIEW

We have already learned something about germs in our previous unit on foods. We know they grow rapidly if they have the proper conditions of moisture, temperature, and food. We say that they often make foods unfit to eat. Someone has said that they exist everywhere and anywhere and that they swarm in the dead bodies of plants and animals and in parts of living bodies as well. They cause decay and, so far as we know, all "catching" diseases. We know that they are alive and form colonies, for we can grow them on food substances in covered dishes. We can see them in the dishes, for they grow in little colonies which may be formed of millions of individual bacteria. The little dots that you may have seen on the jelly in a culture dish are formed by millions of them. On the other hand, it requires a very powerful microscope for us actually to see individual bacteria and, if they are alive, they may be seen as little rods, corkscrews, or tiny round spheres in the fluid in which they grow.

Bacteria are useful as well as harmful. Did you ever think of a world without decay, — all the plants of the garden, the trees, the fish in the ponds, animals wild and domestic, lying about where they happened to die, but without decay taking place? Rivers would be stopped up, ponds filled, dead bodies everywhere. The surface of the earth would soon be covered with dead things. Germs cause things to decay and without germs no decay would

take place. Bacteria also give flavors to foods. Some people like the odor and taste of sauerkraut, of buttermilk, or meats which have become gamy, and in some parts of the world the natives will refuse to eat food that has not become partly decayed. But like all other fungi, such as molds, yeasts, and rusts, they do not manufacture their own food. While many plant diseases are caused by molds or other forms of fungi, such as the blights, wilts, and rots in plants, some of these diseases are caused by bacteria. In animals we have such diseases as anthrax, tuberculosis of cattle, hogs, and chickens, cholera in chickens, glanders, etc., caused by bacteria, while in man there is a long list of dangerous diseases also caused by them. It will be the purpose of this unit to learn something of the ways of these bacteria, good and bad, and to see how man controls them in his environment.

Before beginning your study of this unit, you should see how much you remember of what you learned in a similar unit last year. You need to build on a firm foundation of science principles. Some are the following, perhaps you can add to the number.

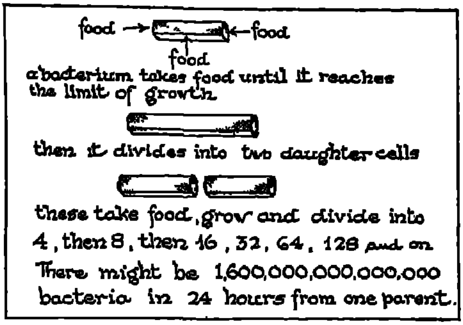
Science Principles

1. Microorganisms, yeasts, molds, and bacteria cause foods to spoil.
2. Bacteria live best on protein food.
3. Foods may be kept from spoiling by keeping at a low temperature or by sterilization (heating).

PROBLEM I. WHAT ARE BACTERIA AND WHAT DO THEY DO?

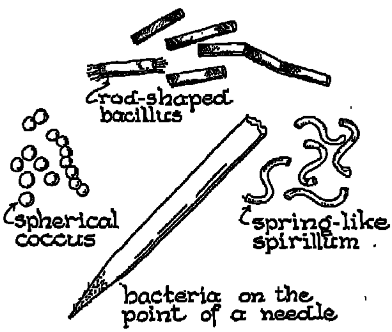
We have already found that bacteria live best on protein foods and that they require moisture and a warm temperature in order to grow rapidly. We have seen that colonies of bacteria are made up of huge numbers of

these little plants, and have found that they are incredibly numerous. A germ that is supplied with abundant food and surrounded by conditions favorable to growth will divide, forming two of its kind in anywhere from twenty minutes to an hour. It is estimated that the germ causing cholera, if allowed to grow at its greatest rate of division for twenty-four hours, would produce 1,600,000,000,000,000 germs and that their weight would be half a million pounds. Of course bacteria actually never get conditions which are absolutely favorable because they are crowded out by others or are killed off.



Why do bacteria not cover the earth?

Size and Shape of Bacteria. Examined under the microscope, these little organisms are found to be single-celled plants. We have seen that they may be rod-like, in which case they are called *bacillus;* ball-like, called *coccus;* or spiral, named *spirillum,* in form. Some of them can move through fluids by means of tiny thread-like structures called *cilia.* They will thrive in moisture, but are usually killed by drying. Many kinds, however, when unfavorable conditions come, form a thick resistant coat about their bodies, and in this condition they are called *spores.* Unfortunately for us, spores are able to



How many shapes of bacteria are there?

resist considerable heat and very unfavorable conditions, and hence they may keep alive even after being boiled for a short time. It is such forms as these that spoil our foods that are poorly canned.

Demonstration 1. Where Are Bacteria Found?

Method. Expose a number of Petri dishes containing nutrient agar for the same length of time in as many of the following conditions as possible.

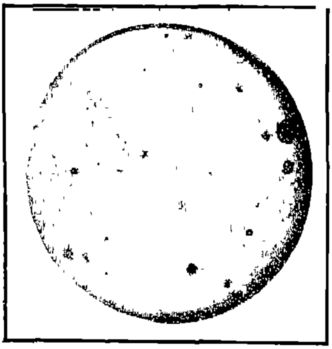
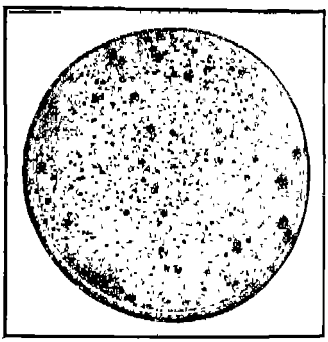
a. Air of the school room.
b. In the halls of the school when pupils are passing to and fro.
c. In the halls of the school when pupils are not moving.
d. At the level of a dirty and much-used city street.
e. At the level of a well-swept and little-used city street.
f. In a city park or quiet square in a small town.
g. In a factory building where there are many people moving.

In other Petri dishes place dirt from the hands, material picked from the teeth with a clean toothpick, a tiny bit of decayed vegetable or meat, two or three hairs from a boy's head, a dirty coin or bill, and any other sources that can easily be obtained.

Cover the dishes and place in a warm, dark place.

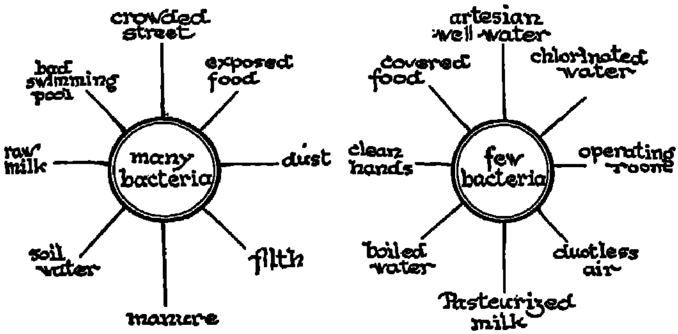
Observations. After three to five days, make observations on the different culture dishes. How are the number of spots or colonies of bacteria and molds growing in each dish? Make a table to show the results.

Conclusion. Where are bacteria found in the greatest numbers and how might these bacteria get into your body?

The left-hand dish was exposed to the air in a clean and well-watered residential district. The right-hand dish was exposed in a crowded and dirty street. How do you account for the differences in the two plates?

Where Are Bacteria Found? The above experiment shows us that bacteria are found almost everywhere in our environment. Bacteria vary with the number of people in the environment. There would be more in a crowded auditorium than in a less crowded classroom, and more in a city street than in the air of the open country. Wherever people live, there are bacteria, and it is only in the high mountains and high altitudes of the free air that the bacteria seem to disappear. In the earth they are naturally found near the surface. As we dig deeper, they become fewer and fewer. In sandy soil there are almost no bacteria and in rich soil containing manure

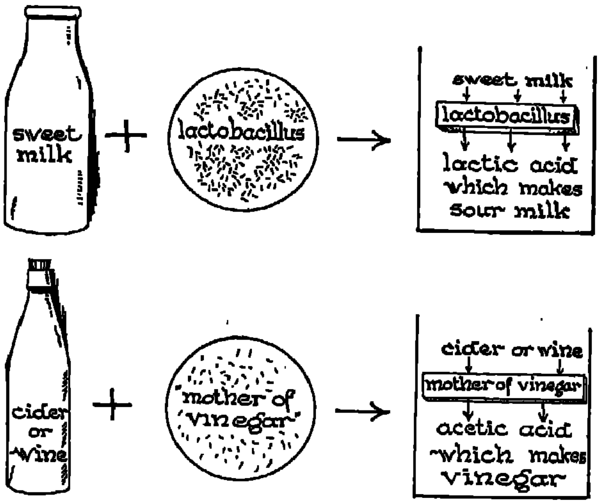


Can you add any places to this diagram? If so, remake it for your workbook.

and dead organic material they swarm in great numbers. They are very numerous in dust and dirt in buildings because such dirt contains decaying materials. Water from artesian and deep wells contains few if any bacteria, but all surface water contains them in great numbers. If the water contains drainage or sewage, it will have untold millions of them. Any water we drink, unless it be filtered and chlorinated, is likely to contain them. We have seen that they give flavor to foods and also cause them to decay. Consequently, damaged fruit, eggs which are not fresh, and meat which has been kept too long will swarm with them. Even in man's body we

find great numbers of bacteria, because food taken into the body often bears bacteria with it, and many of us have the bad habits of putting things into our mouths or sucking our fingers. The lower part of the food tube is literally alive with bacteria. They got in there with food when we were small children and have become messmates. Most of these are useful because as they feed they break down particles of undigested food into a condition in which some of it can be absorbed, while the refuse is passed from the body.

What Do They Do to the Substances on Which They Grow? First of all, they break the foods down into many materials which are called products of decay. In decay there seem to be two stages, an early stage in which we get extremely foul odors, and a final stage in which the odor disappears and the decayed material is broken down into more simple substances. Bacteria cause the decay of all things on the earth, and this makes them among man's most useful friends. They give



What other changes are caused by bacteria?

flavors to food. They cause milk to sour, thus aiding in cheese making. They cause cider or wine to become vinegar, and are found in great numbers in the mother of vinegar. In soil they are of the greatest value to man because they not only break down the material of the soil into such a form that it can be used by plants, but they also actually place new nitrogen in the soil in a state in which it can also be used by plants.

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

nowhere	animals	heat	hydrogen
overcrowding	everywhere	dryness	plants
fatty	soil	flavors	minerals
protein	carbohydrate	enemies	decay
reproduce	spores	food	tiny
moisture	oxygen	nitrogen	divisor

Bacteria are (1)____ (2) ____ which thrive in conditions of moderate (3)____, abundant (4)____, and plenty of (5)____ food. They (6)____ very rapidly and were it not for their natural (7)____ and for (8)____, they would soon cover the earth. They are very useful because they cause (9)____, give (10)____ to certain foods, and help plants to get the (11)____ out of the (12)____. They are found almost (13)____ in nature and are able to resist unfavorable conditions by forming (14)____. They reproduce by (15)____.

PROBLEM TEST

Mehitabel Hopes to Teach Science and Has Made Out This Test for You

Method. Beef broth, a good food for bacteria, was boiled and, while still hot, was placed in a test tube (*A*) just taken out of boiling water and immediately plugged with sterile cotton wool. Another lot of broth was placed in another clean test tube (*B*) which had been exposed to the air for some time, and which was also plugged with sterilized cotton wool. After a week, the two tubes were opened. Was there any difference in the contents of the two tubes?

Check the following statements that give the best answer to the problems.

1. The contents of the two tubes were unchanged.
2. The contents of tube *A* smelled as if decay had taken place, but tube *B* was unchanged.
3. The contents of tube *B* smelled as if decay had taken place, but tube *A* was unchanged.
4. The contents of both tubes smelled of decay.

Check the following statements which give the reason for the answer or answers checked above.

1. The fact that the broth was hot when put in the tube prevented decay from taking place.
2. The fact that the cotton plug was sterilized kept decay from taking place.
3. Bacteria from the air got in while the hot broth was being poured into the tubes, thus causing decay.
4. No bacteria could get into the tubes, so both remained unchanged.
5. The fact that tube *A* was sterilized while tube *B* was not was sufficient to allow growth of bacteria in tube *B*.

PROBLEM II. USEFUL BACTERIA AND THEIR WORK

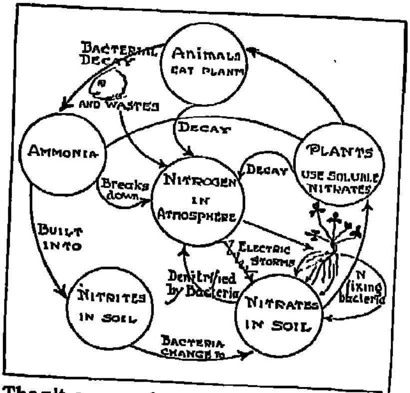
Plants Take Nitrogen from the Soil. One very necessary element in the composition of living matter is nitrogen. Nitrogen makes up nearly four fifths of the air around us, and yet it is not available for use by plants until certain bacteria in the soil have acted on it. Some of these bacteria live in little *nodules* or lumps on the roots of clovers, peas, beans, and other plants called *legumes* and have the power in some mysterious way to take some of this nitrogen out of the air and fix it so that it becomes usable in the soil as plant food. Nitrogen in the bodies of dead plants and animals also is acted upon by the bacteria which cause decay, and is eventually made into soluble mineral substances called *nitrates*. The changes through which nitrogen passes are too complex for us to explain at present, but we should remember that in all the world it is in circulation, from the bodies of living

plants and animals to the soil, there to be changed into soluble nitrates which may be absorbed by the roots and used by the plants again.

Nodules on roots of soybeans. What organisms are contained in these nodules and what do they do?

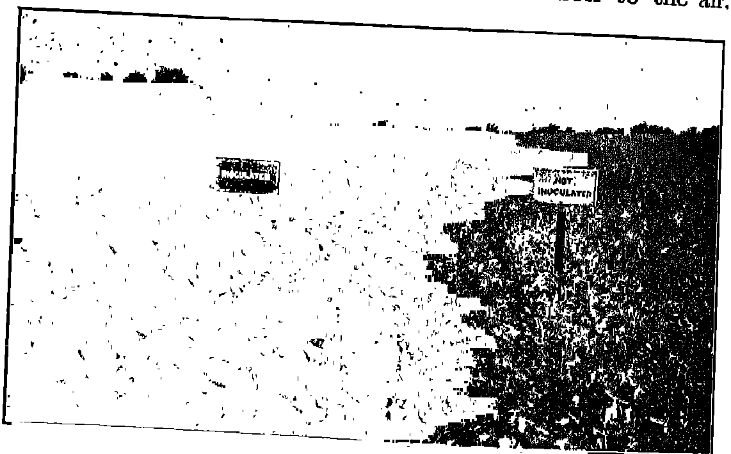
The Living Things in the Soil. Life in this world consists of a great deal of give and take. Plants could not get along without dead organic matter. We have seen the need of manure and other decayed materials. Garden soil must be thought of as a place where millions of bacteria and other plants and animals live, some friendly and some unfriendly to the plants which are desired in the garden. Most bacteria are found within six inches of the surface. An examination of sandy soil has shown something like 100,000 bacteria to the gram, which is about $\frac{1}{28}$ of an ounce; in the soil of an ordinary garden, 1,500,000 to the gram, while in the soil surrounding privies and cesspools, as many as 115,000,000 to the gram may be found.

Work of Soil Bacteria. Bacteria in the soil break down organic material, such as dead bodies of plants and animals, and help to oxidize it. Some nitrifying bacteria act upon ammonia (a product formed in decaying matter) and change it to *nitrites,* while others change these nitrites to *nitrates,* which can be used by plants. Still other bacteria, as we have seen, are found living upon the



The nitrogen cycle. Follow the arrows and find out what becomes of the nitrogen.

roots of certain plants, such as clovers, peas, and beans. These bacteria, although they live at the expense of the plants to which they attach themselves in little nodules, take the nitrogen out of the air which is held in the soil, and change it into a form that can be used by the plants. In the end the bacteria have reduced nitrogenous substances to a soluble form which can be absorbed through the roots, thus repaying the plants on which they live. Sometimes a good farmer buys a culture of these bacteria and puts them into the soil, or *inoculates* his soil. The *denitrifying* bacteria which are commonly found in poorly drained soils release the nitrogen in the soil to the air.

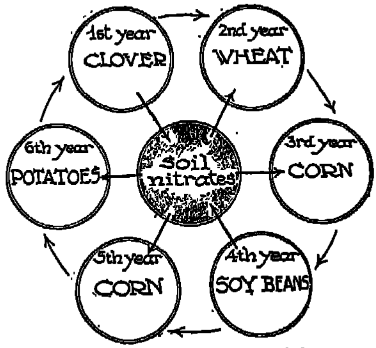


U. S. Dept. of Agriculture

This experiment shows what inoculation of legumes does for the crop.

Are these useful or harmful? Why? In some soils, a little one-celled animal is found which feeds upon useful bacteria, thus destroying the fertility of the soil. It has been discovered that if the soil thus infected is heated for a short time, it will kill these little animals and leave the useful bacteria alive, thus making the soil fertile again.

Reasons for Rotation of Crops. It is common knowledge among boys and girls who have gardens that the soil "wears out" after a while, and that it becomes necessary either to add manure, which contains nitrogen in a usable form, or some artificial fertilizer which contains nitrates, phosphates, and potash. By raising peas, alfalfa, or clover, we can often bring back the soil to its former state of fertility and richness in nitrogen. A boy who wishes to get the most out of his garden will rotate the crops, or make a combination planting. A good combination of two crops in a year would be early peas followed by tomatoes, squash, or sweet corn; or radishes, lettuce, or spinach followed by lima beans or string beans; or string beans followed by celery, cabbage set out from plants, beets, carrots, or turnips.



This diagram shows a successful crop rotation plan. Can you suggest any others?

Fermentation. You all know that when bread rises, it becomes filled with little bubbles of gas. These bubbles come from the growth of yeast cells in the dough. The yeast feeds upon the flour and water, breaking the starch down into carbon dioxide and alcohol. This process, which is known as *fermentation*, is used on a large scale

in the making of beer and wine. Yeasts are mostly responsible for fermentation, but bacteria also play a part. The souring of milk is also a kind of fermentation which is caused by bacteria. When cider or wine changes into vinegar, it has been caused by the growth of bacteria which changes the alcohol into acetic acid and gives it the sharp flavor so much desired by the housewife. Butter and some cheeses are given flavor by bacteria. The curing of black tea, the preparation of cocoa, the manufacture of indigo, the preservation of ensilage as fodder to be placed in the silo, the curing of tobacco, the retting of flax, and the tanning of leather are all made possible with the help of bacteria.

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

fixed	leaves	yeasts	tanning
leguminous	nodules	rich	roots
water	absorbed	fixing	molds
stems	decay	harmful	soil
air	bacteria	unfixed	curing
poor	retting	fix	useful

Many bacteria are (1)____. Such are those that live in (2)____ on the roots of (3)____ plants and (4)____ nitrogen from the air so that it can be (5)____ by the (6)____. Many kinds of bacteria are found in (7)____ soil, where some cause (8)____ and others do harm by releasing the (9)____ nitrogen in the soil back to the (10)____. Fermentation is caused by (11)____ as well as (12)____. Many processes, such as the (13)____ of leather, the (14)____ of flax, and the (15)____ of tea, make use of the work of bacteria.

ESSAY TEST

Is Charley a Good Farmer?

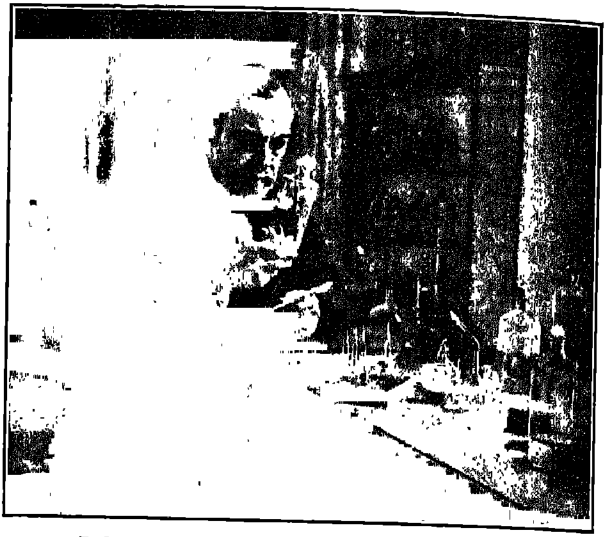
Read carefully and critically. List all the errors and suggest corrections.

I am going to be a scientific farmer when I grow up, and will prove it right now. I know that there are certain kinds of plants

called legumes which include peas, beans, corn, asparagus, and alfalfa. These legumes are able to take nitrogen out of the air and fix it with other substances in the soil to form nitrates which are compounds of nitrogen in a form that can be absorbed by the roots of plants. They do this by means of little animals that live in tiny swellings on the roots of legumes. I would plant my farm with alfalfa the first year and after harvesting the crop, I would plow under the roots of the alfalfa on which were the swellings, for this would give up the fixed nitrogen to the soil. Then the following year I would plant garden vegetables and would continue to do this for several years because I know I would get good crops. This is called rotation of crops. A good farmer sometimes purchases a pure culture of these nitrates and inoculates his soil with them, and this makes his land fertile for many years.

PROBLEM III. HOW AND WHY BACTERIA CAUSE DISEASE

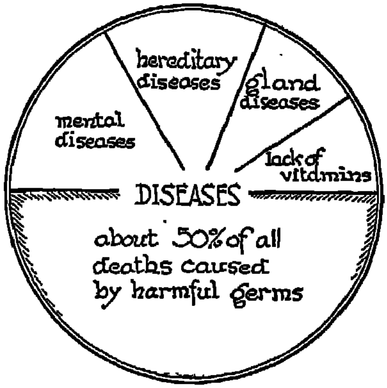
We have thought of the human body as a machine. Machines wear out in time, and so do our bodies, but nevertheless there are very few deaths caused from old age alone. The human machine may slow down but does not stop running unless some defect causes trouble. There are various diseases that are not caused by germs; such are the deficiency diseases caused by lack of some vitamin in the diet; diseases caused by some lack of balance in the working of the glands which make our body run smoothly; hereditary diseases such as epilepsy or habitual drunkenness; diseases caused by bodily defects, such as headaches brought about by eyestrain; and mental diseases. But in spite of all this long list, it is probable that about 50 per cent of all the deaths are caused by harmful germs. Some people do not believe that germs cause disease, but it is easy to prove they are wrong because germs that are known to cause certain diseases in man can be placed in the bodies of rats or guinea pigs or rabbits, and these animals will be given the same disease. You might ask how this is done. We know from experience that a germ disease



LOUIS PASTEUR, 1822-1895.

THE school children of France, when asked to name the greatest man their country had ever produced, chose Louis Pasteur. But if you had known him as a young boy, you would not have thought this honor could possibly come to him. Born in Dole in December, 1822, in very moderate circumstances, the boy grew up as a very ordinary student, and in none too good health. He was sent away to school, and became much interested in fermentation, which up to this time was thought to be a purely chemical process. He showed it to be caused by living yeasts and bacteria found in dust and in the air. He studied the disease of the silkworm, and, after many years of hard work, discovered the causes of the trouble. But we remember him as the man who first understood the meaning of inoculation against disease. He found one day, after inoculating some chickens with a weakened culture of chicken-cholera germs, that if these chickens were later inoculated with deadly cholera germs, they did not become sick. This gave him the idea of the use of a weakened virus against disease and later resulted in the saving of thousands of lives of those threatened with hydrophobia. This principle, now applied in vaccination against typhoid and other diseases, is one of the greatest discoveries of modern medicine. As a result of his investigations, there was built for him the great research laboratories of the Pasteur Institute in Paris. He died in 1895, the most loved man in all France.

is always specific, for a certain kind of germ causes only one kind of disease. It is possible to scrape the throat of a person who has diphtheria and to inoculate a sterile Petri dish containing sterile culture medium with these scrapings. If the dish is placed in a warm place, colonies of bacteria will soon appear on the surface of the culture medium. If, now, a little of the material from one of the colonies which are known to be diphtheria germs is transferred on a sterile needle to a test tube containing sterile culture medium, a *pure culture* of these particular germs will grow in the tube. The tube now contains only one kind of germ and these germs, if introduced into the body of a guinea pig or rabbit, will cause the animal to have diphtheria. We know it is the same disease because the germs of the same kind as the germ in the pure culture can be taken from the animal's body. This has been done time and time again, so that we are now sure that certain specific germs cause certain diseases. To make the matter even more certain, people have sometimes accidentally taken some of these germs into their bodies and they have come down with the same disease.



What can you do to improve the conditions shown here?

Why Bacteria Cause Disease. Suppose you were to take into your body the germs of some infectious disease like diphtheria. These germs would always come from someone who already had the disease germs in their throats. They might be passed on to you by kissing,

drinking out of the same cup, eating an apple, or sucking candy which had touched their mouths, or more usually the germs might be passed along in the mouth spray, as in talking or sneezing or coughing. For a short period, varying from a day or two to about three weeks, these germs live in your body and multiply. This period of growth is called the *incubation* period. During this

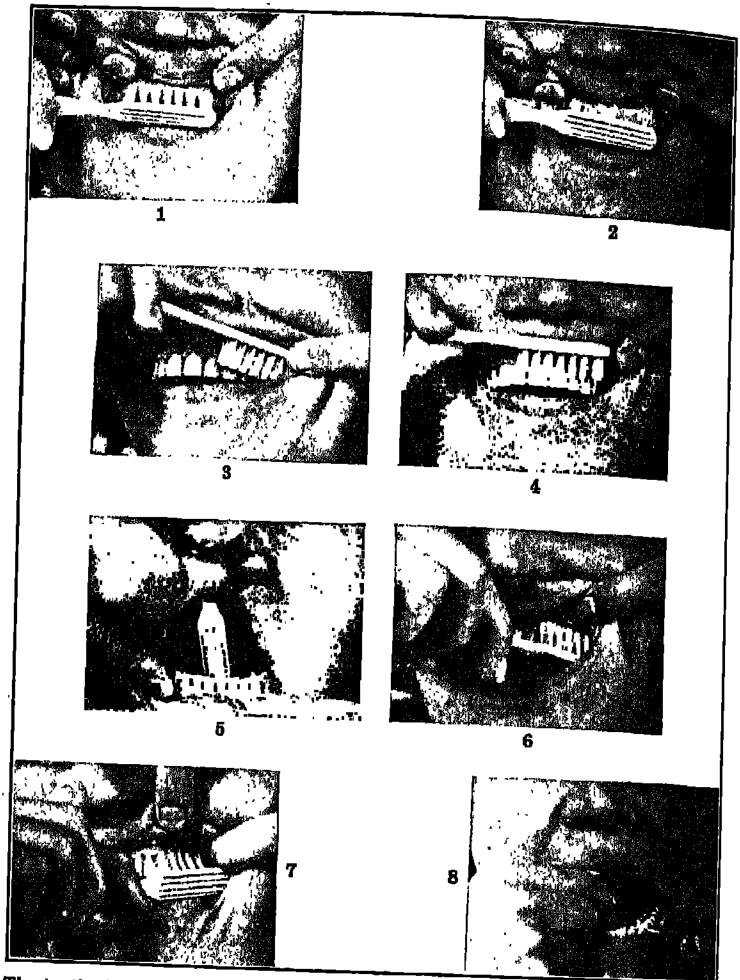
What are some of the dangers that come from riding in a crowded street car?

time the germs are multiplying from a few to many, many millions. As they grow they give off wastes, just as we do in our daily life. But the wastes of the disease germs are poisonous and for that reason are called *toxins*. As these toxins increase, they circulate through the body in the blood, and before long come the symptoms of the disease. Most children's diseases begin with the same symptoms, a slight cold, headache, nausea, and fever. As more and more toxins are manufactured by the germs, the fever and other symptoms increase and we are finally ill with the disease. This story is repeated with variations for practically every germ disease. In some diseases, the toxins cause us to break out with a rash and

in the case of diphtheria the throat becomes very inflamed and may become completely stopped up with a growth caused by the bacteria. In a few diseases, as tuberculosis, the germs may actually eat away the parts of the body where they are living, but in most cases the damage is done by the toxins. And, unfortunately, germ diseases often leave dangerous aftereffects, as would be true of any poison taken into the body.

Why Are the Teeth and Tonsils Danger Points of Infection? Since germs enter the body largely through the mouth and nose, we should be sure that all parts of the mouth, nose, and throat are kept clean. Proper brushing of the teeth and care of the mouth may keep the teeth healthy, but we often find that in spite of all that we do, germs attack the teeth and sometimes form little pockets at the base of the root. These pockets of germs give off their poisons into the blood supply and each alone becomes the focus or center of infectious materials which may lead to very serious troubles, such as rheumatism and heart trouble. Infected teeth may be readily discovered by the use of X-ray's and usually should be extracted. Pyorrhea (pī′ŏ-rē′ȧ) is a disease of the gums which causes the teeth to become loose. This is another source of infection and should be treated by a good dentist. Get the habit of going to a reliable dentist at least every six months and always take his advice.

The tonsils are masses of tissue at the entrance to the throat and may harbor germs. Cases of sore throat and tonsillitis are indications of the presence of germs. When air is taken in through the nose, the moist lining of the nose warms and moistens the air and prevents irritation. The small hairs in the nasal passages will catch and hold some of the dust and germs that may enter with the air. The tonsils lie on the side walls of the throat and are composed of spongy tissue. If they become enlarged, they



1 2 3 4 5 6 7 8

The teeth should not only be brushed from side to side (shown in 1 2) to remove the surface film of bacteria, but they should also be brushed from base to tip as is shown in figures 3 and 4. Then the back part should be brushed as well as the front (figure 5). The irregular crowns of the big molars should also receive a brushing (figure 6) and finally the gums should have a massage (figures 1, 2, and 7). This brings blood to them and keeps them healthy. Finally at least once a day use dental floss between the teeth to get out particles of food that may cause decay (figure 8).

are likely to become infected with germs taken in with the air. Infected tonsils should be removed. Adenoids are spongy growths of tissue which often fill up the air passages in the back part of the nose and thus cause difficulty in breathing, with a consequent loss of efficiency. They may be removed by a very slight operation. Other areas sometimes attacked by bacteria are the spaces in the bones of the nose and face known as sinuses; such infections are a cause of much discomfort and require careful treatment by physicians.

SELF-TESTING EXERCISE

From the following list of words select those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

symptoms	uncertain	toxins	contact
specific	disease	hereditary	particular
deaths	transform	infects	multiplying
50 per cent	more	less	eating
germs	same	75 per cent	grows
minerals	little	diseases	incubation
germ	knowledge	vitamin	having
transferred	grow	talking	well

Probably (1)____ of all (2)____ are caused by germs, although this proportion is growing (3)____ each year due to the better (4)____ of germ diseases. Animals used experimentally show clearly that certain kinds of (5)____ causing (6)____ which can be grown in the laboratory, if (7)____ to a guinea pig or rabbit, will cause the animal to have the (8)____ (9)____. Germ (10)____ are thus shown to be (11)____. In passing an infectious disease, the germs must be transferred from a person (12)____ the (13)____ to a (14)____ person. This may come through (15)____ by sneezing or coughing or even (16)____ close to another person, or by using the same (17)____ utensils, as glasses, forks, or spoons. After the germs are transferred, they (18)____ in the body of the (19)____ person, (20)____ rapidly and giving off (21)____ which cause the (22)____ of the disease. This period of early growth is known as the (23)____ period, and is the time when most infectious diseases are (24)____ from one person to another.

PROBLEM TEST

Sylvia Has Prepared a Test for You

Method. A tiny bit of pus from a boil was transferred with a sterile needle to a sterile culture medium in a sterile dish and placed in a warm place for several days. Several different kinds of colonies of bacteria were found in the culture medium. Explain.

Check the best probable reason or reasons for this happening.

1. The person transferring the pus got bacteria in it from his hands or the needle used.
2. The air was filled with various kinds of bacteria, which got in the sterile dish when it was opened.
3. The pus contained more than one kind of bacteria.
4. The culture medium contained germs.
5. The dish contained germs.

THE REVIEW SUMMARY

In preparing a summary of what you have found out in this unit, you will want to place emphasis on the big ideas which have come from the applications of the facts you have learned and the demonstrations you have seen. Doubtless you have done some additional reading which has helped you put together some of the facts into generalizations or fundamental underlying principles. For this unit some of these generalizations are:

1. Bacteria are found almost everywhere.
2. Bacteria can be caught, isolated, and grown in a pure culture in the laboratory.
3. Bacteria reproduce very rapidly.
4. Some bacteria enrich the soil by taking nitrogen out of the air.
5. Specific bacteria cause specific diseases.
6. Catching diseases are caused by bacteria.

Before making your review summary for your workbook, test your knowledge of the facts of the unit by checking over the text so as to be sure you know the facts underlying the science principles or generalizations. Then using this material and everything you

have read, seen, or done yourself, make your summary outline. This outline you may use when you make a recitation.

TEST ON FUNDAMENTAL CONCEPTS

In a vertical column under the heading CORRECT *write the numbers of all statements you believe are true. Under* INCORRECT *write the numbers of the false statements. Your grade = right answers × 2½.*

I. **Bacteria:** (1) live best under conditions of great heat; (2) thrive on most protein food; (3) are all microscopic; (4) multiply very rapidly under favorable conditions; (5) prefer dryness to moisture.

II. **Bacteria are found abundantly:** (6) in the digestive tract; (7) in sandy soil; (8) in manure; (9) in chlorinated water; (10) in some kinds of cheese.

III. **Bacteria are useful because:** (11) they kill off the excess population; (12) they cause wood to rot; (13) they fix nitrogen from the air; (14) they cause decay; (15) they sour milk.

IV. **Nitrogen-fixing bacteria:** (16) are found on the roots of plants living in rich soil; (17) take nitrogen from the bodies of dead plants and pass it on to living things; (18) absorb soluble nitrates from the soil; (19) fix free nitrogen from the air, changing it to soluble nitrates; (20) live in nodules on the roots of leguminous plants.

V. **Fermentation:** (21) is a chemical process; (22) is brought about by yeasts and certain bacteria; (23) causes bread to rise; (24) aids in the process of making vinegar; (25) causes the formation of alcohol in making wine.

VI. **We know bacteria cause disease because:** (26) germs causing a certain kind of disease can be transferred from one animal to another and will cause the same disease in the second animal; (27) people take "catching diseases"; (28) we can make a pure culture of disease germs and then give the disease to a rat by inoculating the animal with germs from the pure culture; (29) they are everywhere and diseases are universal; (30) they grow freely in moist protein.

VII. **We call a disease catching or infectious when:** (31) it is caused by germs; (32) when it can be passed from a person who is sick to a person who is well; (33) when a person has a fever; (34) when a person has a headache; (35) when it shows an incubation period.

VIII. **Focal infections:** (36) often cause serious diseases; (37) are caused by bacteria; (38) are caused by diseased teeth or tonsils; (39) cause adenoids; (40) may be prevented by brushing the teeth.

PRACTICAL PROBLEMS

1. How would you go to work to determine scientifically whether or not a disease was caused by bacteria?

2. Do you know of any other ways of making compounds out of the nitrogen of the air except by means of the nitrogen-fixing bacteria? Explain.

3. Certain people deny that germs cause disease. What facts could you bring forward to disprove this?

4. Alice's small brother who does not go to school is ill. His eyes and nose "run" and he has other symptoms of coming down with a cold in the head. Alice has played with him all afternoon. What should she do about going to school next morning?

INTERESTING THINGS TO DO, READ ABOUT, OR SEE

1. Work out a plan to catch and grow wild yeasts.

2. Work out a plan for a demonstration to prove that bacteria are found in milk.

3. Read De Kruif's *Microbe Hunters*, Hallack's *Health Heroes*, or Vallery-Radot's *Life of Louis Pasteur*.

4. Make a list of all the superstitions held by your class with reference to disease, and show where each one is unscientific.

5. Make a survey of the class to see what catching diseases each one has had. Find out at what age each disease was taken.

SCIENCE FOR LEISURE TIME

1. Plan an experimental garden in which you use exactly the same kind of soil throughout, but use different ways of fertilizing the soil. Compare the differences obtained by using inoculations with nitrogen-fixing bacteria, with commercial fertilizer, and with rotation of crops, using alfalfa or soybeans.

2. Work up a report on a series of crops which would make a good rotation for your garden.

3. Prepare a large chart on "Who's Who among the Microbes."

4. Make a labeled collection in small bottles of different kinds of legume seeds. Place your collection on exhibition.

SCIENCE CLUB ACTIVITIES

1. Plan and give an exhibit in which you show the ways in which man can control the growth of bacteria. For this purpose plan experiments that show the effect of (1) temperature, (2) moisture, (3) light, and (4) food. Be sure to have each experiment original and use a control.

2. Go to the local health department and find out where you can get material to make some large chart graphs to show seasonal variations in disease. Put these charts on exhibition.

3. Prepare an exhibit of clippings and pictures on the milk industry in your locality.

4. Make a field trip to obtain good specimens of nodules on the roots of leguminous plants, and exhibit them.

5. Plan a meeting at which a debate is held on the subject — Resolved: that the world needs bacteria.

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Survey Questions

In what ways might your surroundings affect your health and that of other people?

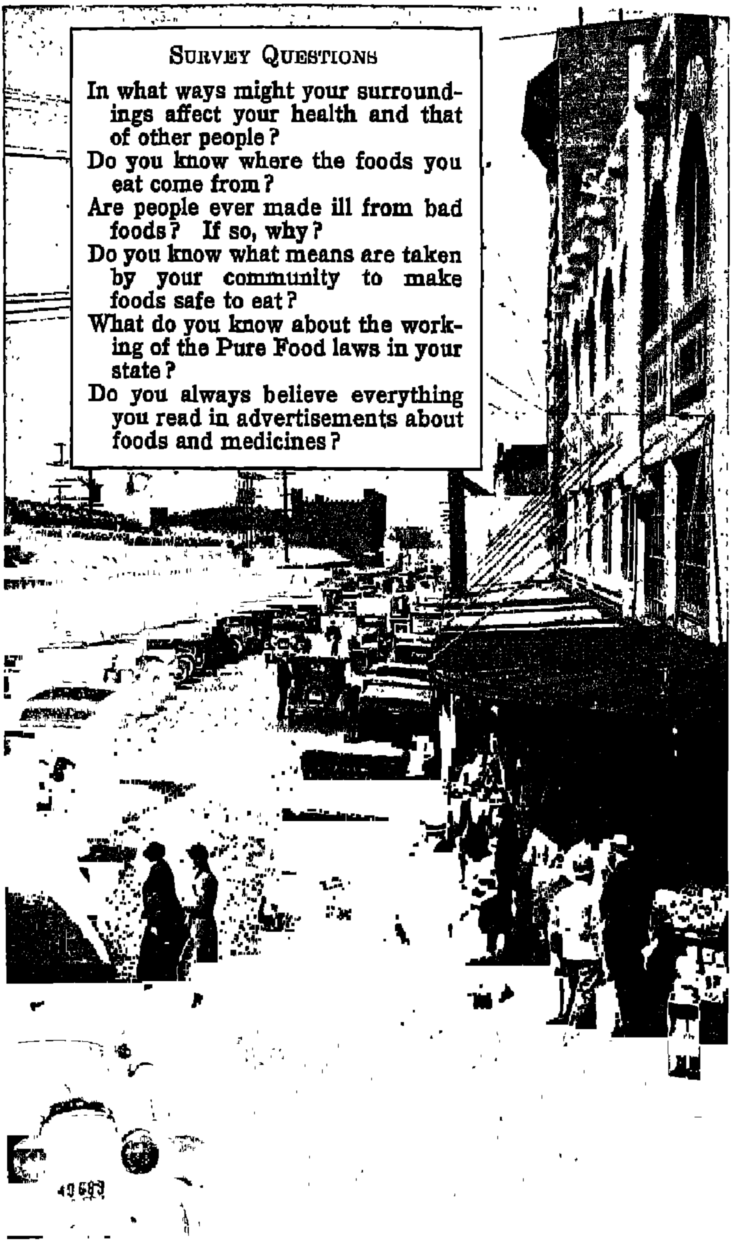
Do you know where the foods you eat come from?

Are people ever made ill from bad foods? If so, why?

Do you know what means are taken by your community to make foods safe to eat?

What do you know about the working of the Pure Food laws in your state?

Do you always believe everything you read in advertisements about foods and medicines?



UNIT XIII

HOW THE COMMUNITY PROTECTS ITS FOOD SUPPLY

PREVIEW

Have you ever been to a public market where vegetables and fruits are brought in from the country, where groceries, meats, and dairy products are placed in pleasing array in attractive booths? How inviting these look when the stalls are clean and the foods are free from flies and dirt, and how we instinctively avoid buying at the places that are slovenly and dirty. Have you ever thought of all that has been done in order to make these foods safe for you? Not only does the United States Government have laws which deal with the protection of foods, but most state governments do as well. Both have a staff of men whose business it is to go from place to place and inspect all kinds of foods which are used in a community so as to keep them safe for human consumption. The milk you drink is inspected at the farms where it is taken from the cow. It is packed in ice and sent in refrigerator or tank cars to the city, where inspectors again examine it to see that it is not contaminated before it is pasteurized and bottled by the great milk companies. In the cities, the health departments supervise the work and also see that fish, meats, vegetables, fruits, and other easily spoiled foods are put on sale under conditions of cleanliness and safety to human beings. Meats bear the mark of inspection by federal officials. Groceries and canned goods are

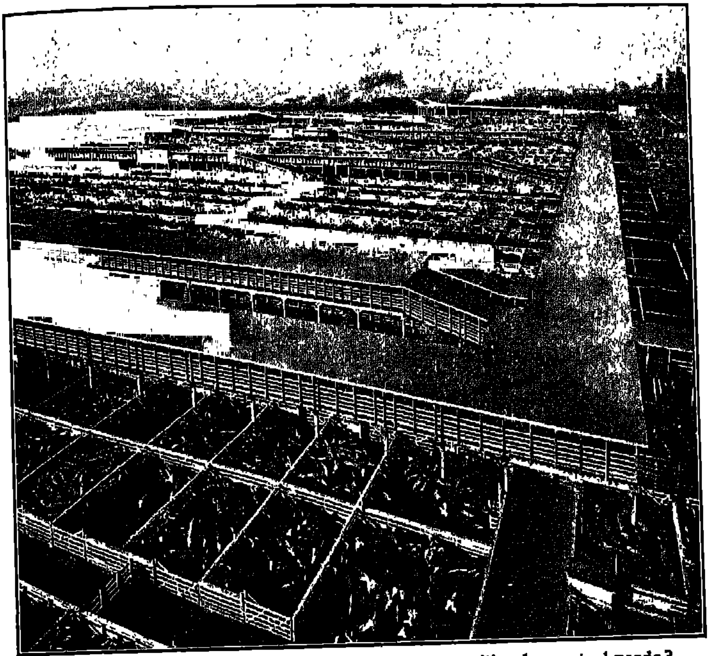
protected from adulteration by pure food laws. All preserved goods are labeled so that each one may know just what preservatives are used. This is done so that no poisonous materials may be put into the preserving substances in quantities injurious to health.

Swift and Co.

Meat is inspected by government officials before it is sold. Read your text carefully to see if this is always done.

Our food supplies come from very many sources. Much of our pork comes from Iowa and Illinois; our lamb from Montana; fruit from California or New York; fish from the eastern or western coasts or from the Great Lakes. Evidently we need inspectors in a great many places. All the stockyards, storehouses, and cold-storage plants must be visited if we are to be safe from bad foods. In the stockyards no diseased animals can be slaughtered, and in the cold-storage plants the inspectors check for decayed food. Even cured meats and canned goods must come under their eye.

It was not so long ago that communities did not take much care of their food supplies, and as a result we had many cases of food poisoning. Today we are better educated, so that most communities have the proper facilities for caring for foods on sale. Some places, however, are not so careful, and although laws may be made, they are not kept. Especially is this true of



Stockyards at Kansas City. What other large cities have stockyards?

smaller places where the members of health boards or other officials do not see the need for close supervision. This is *your* opportunity to do your duty as a young citizen. Are there farms near where you live that produce dirty milk? Are there stores in which milk is sold in cans unprotected from flies and dirt? Do you do your part at home in protecting your milk and other foods in hot weather? Are your food supplies bought when fresh and used when fresh? Do you read the labels on your canned goods and preserves, and do you know what these labels mean? If you are to be a really useful member of your community, you should not only know the pure food laws and their meaning, but also you should do your part in making it possible to carry out these laws.

Before you begin the serious study of this unit, you will want to recall all you learned last year about foods, so that you may build this unit on a firm science foundation. These are the following:

SCIENCE PRINCIPLES

1. Foods come from living and non-living sources.
2. We need a variety of foods to keep healthy.
3. Foods are used for growth, energy, and the regulation of bodily activities.
4. Vitamins are essential to health.
5. Microorganisms cause foods to spoil.
6. Refrigeration, drying, preserving, and cooking protect foods from microorganisms.

Keep these statements in mind as you study the pages that follow.

PROBLEM I. WHY SHOULD FOOD SUPPLIES BE PROTECTED?

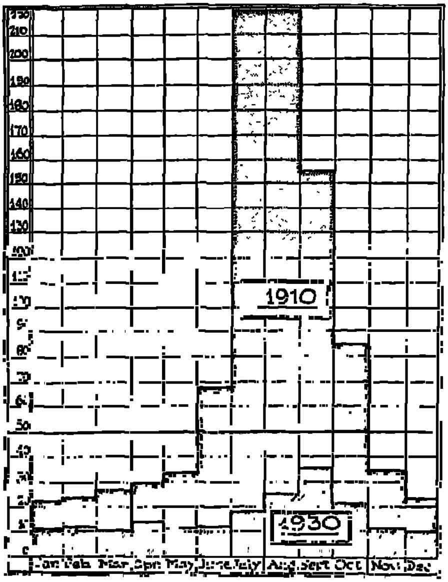
Some Reasons Why Foods Must Be Protected. We hear a good deal nowadays about pure food, and people are becoming educated to the necessity of having food neither contaminated nor adulterated. Not so long ago many of our prepared foods were adulterated. Of many samples of foods tested before the year 1906 at Washington, 50 per cent of one lot of 500 samples, 41 per cent of another lot of 500 samples and 60 per cent of a third lot of 500 samples were found to be adulterated. This showed to the Congress of the United States the need of protecting people against the adulteration of foods, and so, in 1906, the Federal Food and Drugs Act was passed. We found also that our meats were not always protected in the killing and in transit to the consumer.

Milk and Water May Be Dangerous Foods. Everyone of us living today is responsible for everyone else.

Health depends on each one's willingness to look out for his neighbor as well as for himself. Foods are materials that everybody uses. We therefore have rights as citizens to expect our foods to be pure, to be kept clean, and to be protected from disease germs. Not so many years ago, when we did not realize the value of protecting our food supplies, there used to be great outbreaks of diseases or epidemics caused by drinking contaminated water or milk or by eating adulterated foods. Hundreds of epidemics of typhoid fever have been traced to water supplies in which typhoid germs were found present. As late as 1903 the city of Ithaca, the site of a great university, had over 10 per cent of its total population sick with typhoid. This was caused by the pollution of its water supply. As recently as the months of March to July, 1927, Montreal, Canada, had an epidemic of 4755 cases of typhoid which were apparently distributed through milk. A report on this epidemic says, "that surface streams were commonly used as sources of water for the milk houses (houses where the milk was prepared for shipment) and for the disposal of sewage from the homes up stream," and in one milk-receiving station, "the water used mainly for washing the cooling vats and other equipment was pumped from the river." Do you see why this epidemic appeared?

Dangers from Raw Vegetables. But other foods besides milk and water may carry disease germs. Unwashed fruits and vegetables, such as celery, lettuce, water cress, or radishes, may sometimes carry germs causing diarrhea or other intestinal diseases, especially if these vegetables have been watered with manure water, as is often the case. An outbreak of typhoid fever has been traced to some people eating water-cress sandwiches. Eighteen out of nineteen people eating this water cress, which came from a polluted stream, were taken ill.

Other Dangers. Badly preserved fruits or vegetables may "work," showing the presence of bacteria. While



Compare the seasonal variation in diarrheal diseases in 1910 and 1930. How do you account for the differences?

such foods are not necessarily injurious, they should be thrown out rather than to risk food poisoning because the deadly germ which causes botulism is sometimes found in such foods. Raw oysters have been known to carry typhoid germs, and as late as 1904–5 an outbreak of typhoid which caused the illness of over 1500 people and the deaths of over 100 was traced to the custom of oyster dealers placing their oysters for sale in fresh or brackish water to "fatten" them. The cars in which the oysters were placed were sometimes floated near the openings of sewers, and the oysters feeding on minute particles in the water took the germs into their bodies. Fortunately this process is now prohibited by law, and people can feel safe in eating "oysters on the half shell." We must remember that flies and other insects may carry harmful germs. Experiments have been made that show very clearly a relation between the number of flies and certain diseases of the food type, such as diarrhea. It is not very pleasant to think of flies carrying germs from toilets to foods, but this is just what they do. Remember during the fly season to protect all foods from these dirty crea-

tures. Also keep all overripe or spoiled fruit and meat which has a slight odor from the table because such foods are likely to contain bacteria that cause decay.

SELF-TESTING EXERCISE

From the following list of words select those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

unhygienic	disease	wealth	food	fruits
bacteria	harmless	milk	habits	foods
nuts	neighbors	eggs	contagious	increased
passed	vegetables	filth	polluted	used
reduced	chlorinated	supplies	edible	places
health	water	clean	filthy	diseases

Each person living today is responsible for his own (1)____ as well as that of his (2)____. All people are likely to have (3)____ or catching diseases and these may be (4)____ on to others through (5)____supplies (6)____by many people. Such are (7)____supplies and raw (8)____ or (9)____. Typhoid fever (10)____ to be one of our most prevalent diseases in (11)____ where the (12)____supplies were (13)____ although today deaths from this disease have been greatly (14)____ because better care is taken of (15)____ and (16)____ supplies. Dirty food is always (17)____ as well as unpleasant to eat. Flies spread (18)____ because of their filthy (19)____. They carry (20)____ from decayed (21)____ and place them on (22)____ foods. We eat the foods and take the (23)____ into our bodies, where certain kinds may cause (24)____.

ESSAY TEST

John Tells Why Foods Ought to Be Protected

Read carefully and critically. List all the errors and suggest corrections.

Everybody has to eat. Many food supplies that are used in common, as, for example, milk, pass through many hands before they reach the consumer. Some people may be dirty, and dirt, if it gets into milk, may cause disease. Foods are not better protected today than they were twenty years ago, hence there is just as much sickness as there was then. Laws are made to protect us,

but we are careless and do not obey them. So we get sick. Fortunately most germs are harmless and so we are not made sick by many of them.

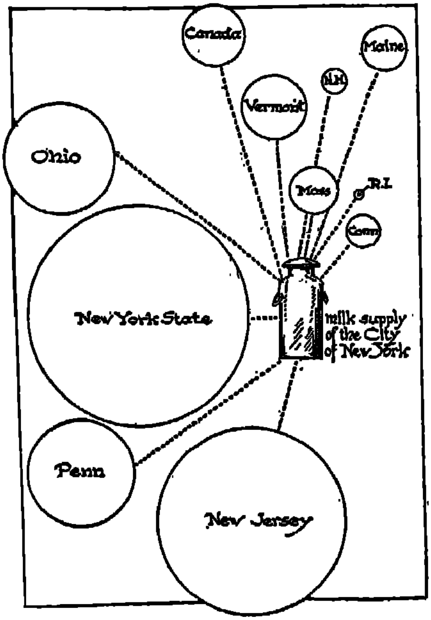
PROBLEM II. HOW ARE WATER AND MILK SUPPLIES PROTECTED?

How Milk Supplies Are Protected. In Unit IV we have already learned how the community protects its water supplies. The protection of milk, however, is a different matter. In order to have pure milk, the greatest care must be taken from the time the milk leaves the cow until the time it reaches the consumer. The purest milk comes from cows which are healthiest and kept in clean yards and barns. Yet, one dirty or sick milker might send his germs through the milk to do harm in the city where it is delivered. Care then must be exercised at every point. In the best of dairies the milking barn is screened to protect the milk from flies, and the workers wear white

R. I. Nesmith & Associates

A model dairy barn. Tell the ways in which the milk is protected.

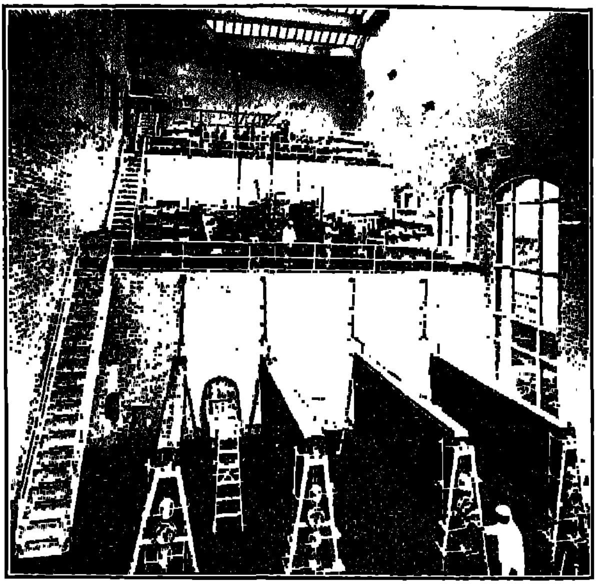
washable clothes and white gloves. In the most up-to-date dairies, when the cows come in to be milked, they are carefully washed, put in clean stalls, and milked by means of electrically-driven machines which take the milk directly from the cow into closed containers. Then the milk is cooled and either placed in cans in a refrigerator car or else delivered to glass-lined tank cars in which the milk is kept artificially cool. When we remember that a city like New York obtains its milk supply from eight different states as well as Canada, and that some of its milk is over four days old when it reaches the consumer, we can see the need, not only for ice in order to prevent the growth of bacteria in the milk, but also for pasteurization. In most cities the big milk companies pasteurize their milk on a large scale by passing it rapidly over pipes filled with steam. This kind of pasteurization, known as the flash method, raises the temperature of milk to 178° Fahrenheit for about a minute. It is not so good as the slow method of heating to 145° Fahrenheit, for 30 minutes, but it kills the harmful bacteria in the milk and slows up the growth of the bacteria which cause the



The milk supply of the city of New York. The size of the circle shows the relative amounts of milk that are shipped from each locality.

milk to sour. Pasteurization will not keep the milk from souring, nor will it make dirty milk clean, but it will keep the clean milk fresh longer. At the present time Massachusetts has about 85 per cent of its milk supply pasteurized, and in consequence milk-borne diseases are at the lowest level they have ever been.

Milk Standards. Many cities, such as New York, have four kinds of milk. The first is *Certified.* This milk must come from cows which are free from all disease and which are examined frequently by inspectors, and when the milk is delivered raw (which means not pasteurized), it must have not more than 10,000 bacteria to the cubic centimeter. To have such a condition means that the barns must be clean, that the cows must be clean at the time of milking, that the workers must be free from dirt and disease, and that the dairy and its cans must be in



Sheffield Farms Co., Inc.

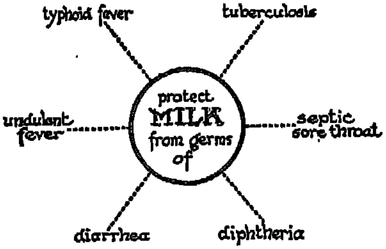
A city pasteurizing plant. Milk here is heated to 178° Fahrenheit for about a minute. Is this the best method of pasteurization?

spotless condition. Milk such as has just been described is very expensive because of the care needed, but it is the purest milk. Grade A pasteurized is milk which must be produced from cows free from disease, the general sanitary conditions must be good, and the bacterial count must not be over 200,000 before pasteurization, and not more than 30,000 before delivery to the consumer. *Grade B* milk, when sold raw must contain not more than 300,000 bacteria to the cubic centimeter and when pasteurized must contain not more than 1,000,000 to the cubic centimeter before pasteurization and not more than 100,000 per cubic centimeter at the time of delivery. There is also a *Grade C* milk allowed which is so low a grade that it should not be used for anything except cooking.

Other Ways of Supplying Milk. In some parts of the world fresh milk is not obtainable. Therefore milk is evaporated and placed in cans, or it is dried to a powdered form and then used with fresh water. Neither of these sources of milk is so good as fresh milk because the vitamin content is harmed.

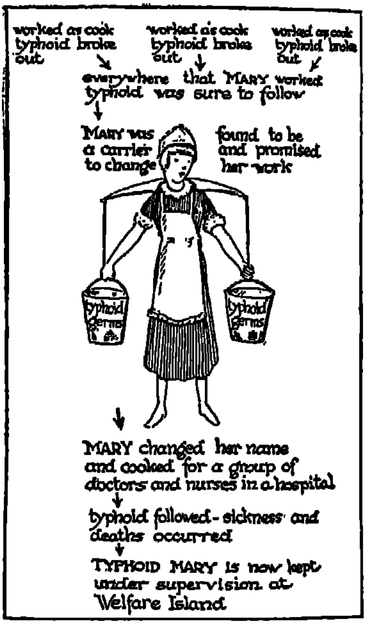
Diseases Passed through Milk. One of the chief reasons why milk must be carefully protected is that of the number of diseases that can be passed on through it. Typhoid, scarlet fever, septic sore throat, diphtheria, and certain cases of tuberculosis can all be carried in milk, while measles, diarrhea, and certain rare diseases, such as undulant fever, are traced to this same source. Although the germ which causes tuberculosis in cows is not the same as that which causes adult tuberculosis in human beings, yet about 30 per cent of the tuberculosis in children under five years of age is the kind that is found in cows. Children are more susceptible to cow tuberculosis than adults, so this makes it all the more necessary to inspect the cows for this disease and prevent their milk from getting into the public supply. There were 317 known epidemics of

typhoid up to the year 1908 which were caused by infected milk and many more since that time, although in recent years, because of our knowledge about germs, the numbers of such epidemics are rapidly decreasing.



Why is it important to protect milk while it is being handled?

The Problem of the Carrier. The greatest danger at present comes from carriers, those people who have had the disease and who still carry the germs in their body. They are not necessarily sick when they carry these germs and in some cases are not known to have had the disease. You have all heard of "Typhoid Mary." She was the first typhoid carrier to come into public notice because, during a period of six years, she infected 24 people with typhoid. She was a cook and carried the germs in her body and because of dirty habits passed them on into the food. She was put under observation for three years, but escaped, and later, in 1914, entered a New York hospital as a cook and there infected 25 more employees. Because our



What other people besides cooks might be dangerous as carriers of typhoid or septic sore throat?

present laws in some states do not allow us to put these disease carriers where they cannot pass on the disease to others, we still have many epidemics traced to them. Between March, 1930, and August, 1932, six out of seven such epidemics of septic sore throat, scarlet fever, and typhoid, involving 277 cases, were definitely traced to carriers. This shows the importance of having all handlers of milk and foods frequently inspected.

SELF-TESTING EXERCISE

From the following list of words select those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

germs	flash	septic	boiled
cold	useful	diphtheria	clean
hot	carriers	smallpox	handling
distance	disease	useful	pasteurized
hours	bodies	transportation	typhoid
days	hold	freezing	pass
can	cow	sheep	oxen

All milk contains germs, even when it comes direct from the (1)____. In order to keep the milk (2)____ care must be exercised in milking, in (3)____, and in (4)____. Milk in large cities may come from a (5)____ and is often over 48 (6)____ old before it reaches the consumer. Therefore, it must be kept (7)____ and should be (8)____ before it is delivered. Large milk companies use the (9)____ method of pasteurization. Pasteurization kills (10)____ germs, such as those causing (11)____, (12)____ sore throat, and (13)____. Most danger today comes from (14)____ or people who carry (15)____ (16)____ in their (17)____ and can thus (18)____ them on to others.

ESSAY TEST

Charlie Tells How to Keep Milk Safe

Read carefully and critically. List all the errors and suggest corrections.

When milk comes from the cow it has no germs in it so care must be exercised at every point to keep milk pure. It should be first carefully strained through cheese cloth, as this takes out any germs

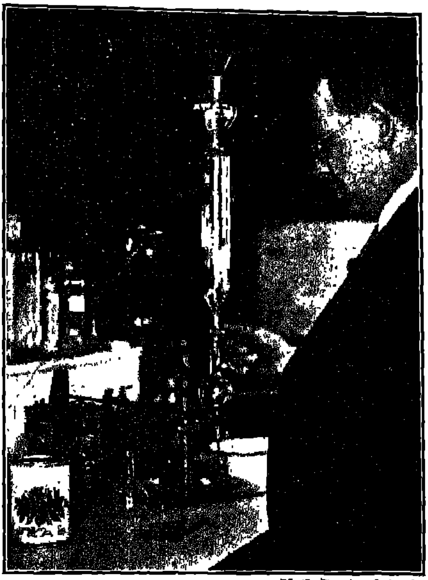
that might get in from the air. Then it should be sterilized before shipping in order to kill the germs. Our greatest danger comes from carriers who carry living germs in their clothing for they can thus pass these germs on to our milk or other foods. Smallpox, diphtheria, septic sore throat, and many other diseases are passed on in this way.

PROBLEM III. HOW ARE FOODS PROTECTED IN STORES AND MARKETS?

Protection of Foods. You have all bought food in a neat store where the foods were clean and protected from flies. You may also have gone to stores that were far from clean, and you have felt that it was better to get food in a clean market. Fortunately for us most cities and states have regulations for the proper inspection and care of food supplies. As a community grows in size, it becomes necessary to safeguard the health of its citizens by protecting all supplies that are used in common. We have seen how water and milk are protected, but we also have means for protecting meats, fruits, vegetables, and canned goods that are sold to the public. The board of health of your town has inspectors whose business it is to see that the foods on the stands are so covered that dust, which contains bacteria, and flies, which carry bacteria, cannot reach them.

How Our Meats Are Protected. All over the United States the government has placed federal inspectors whose business it is to see that all animals killed for meat are in good condition. These inspectors work in the great slaughterhouses and packing houses. Work is carried on in over 250 cities and in over 3000 different large establishments. Meat is inspected by government officials for bacteria that cause tuberculosis and suspected meat is destroyed. The kinds of clothes the workers wear in the plant, the appliances for sterilizing buckets, knives, tanks, etc., and the method of control of pests are all regulated

by law. In many cities the slaughterhouses must be rat proof, screened against flies, and all refuse must be at once disposed of. Unfortunately our National Government no longer examines pork for the presence of the pork worm or trichina. These worms bore into the muscles of pigs, and there make cases around themselves. If pork in which the worms are still alive is eaten they will get into the food tube and reproduce there. The young will later work their way into the muscles of their host, there causing serious inflammation and sometimes death. Always be sure that all fresh pork is thoroughly cooked as we have no protection other than this against the trichina.



U. S. Dept. of Agric.

Testing canned vegetables in the laboratories of the Food and Drug Administration.

The Sale of Meats, Milk, and Groceries. One of the most important functions of your board of health is to see that the stores in which milk, meats, fruits, and groceries are sold are clean and sanitary. In many communities the law provides that all perishable goods must be kept under glass or well screened, especially in the summer season. Can you see a reason for this? Does the grocer with whom you deal have a clean and well-ventilated shop? Are the receptacles containing flour, sugar, etc., always kept covered? Are vegetables

and fruits exposed so that people may handle them and flies and other vermin touch them? If so, you should not patronize the place. Food, when exposed for sale, should be kept covered so that germs cannot get to it, for this is one of the easiest ways for germs to be spread. Suppose a man with tuberculosis should come into the shop and cough on the fruits, vegetables, or into an open can of milk. What would prevent you from innocently carrying home those germs and taking them into your own body? An ounce of prevention is worth several pounds of cure in this case.

Cold Storage and Its Relation to Foods. Are cold-storage foods as safe to eat as fresh foods? We often hear this asked. It is true that the cold-storage plants, which have come to be almost a necessity for large communities, frequently keep meats, fish, and other foods for periods of from several weeks to several months, or even

Galloway

Street markets. Is this a safe way to buy food? Give your reasons.

longer. While storing foods in ice at a freezing temperature changes their flavor, yet if the food is *fresh* when it is put in cold storage and if it is used soon after it is taken from cold storage, it will be good to eat. Foods kept in cold storage a long time are softened so that bacteria grow rapidly in them. Sometimes fish or meats are put into cold storage after the bacteria have begun to spoil them. Such foods would be unfit to eat after coming from cold storage. On the whole, cold storage is a boon to modern society, for it enables us to have fresh vegetables, eggs, and other perishable foods at times when they could not otherwise be obtained.

The interior of a cold storage plant. Most meat used today comes from cold storage.

Frozen Foods. A new process by which foods are frozen rapidly and then kept at a temperature below freezing has resulted in the placing on the market of many kinds of meat, fresh fruits, and vegetables. Experiments have been made which show that if these materials have bacteria on them before the time of freezing, they are likely to carry them alive during the time of storage. It is therefore necessary to treat such foods as we would any other freshly bought vegetables, that is, they should be carefully washed or sterilized before using. Such vegetables also spoil very quickly after defrosting.

Another frozen food which requires careful sanitary

control is ice cream. Recently 250 samples of ice cream were collected from various stands and stores in a certain city. These samples showed from 37,500 to 365,000,000 bacteria per cubic centimeter, depending upon the sanitary conditions in the ice-cream factory and the care in which it was handled. It is believed that 100,000 bacteria per cubic centimeter is the limit for safety, so you can see that some of this ice cream was very bad indeed.

SELF-TESTING EXERCISE

Select from the following list those words which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

fat	health	trichina	raw
perishable	used	cooked	well
covered	usable	scarlet fever	state
hookworm	local	lean	inspected
Federal	tuberculosis	keep	roundworms

Because of the dangers which may come from decayed or infected foods (1)____, (2)____, and the (3)____ governments all have a part in protecting us from the dangers coming from such foods. Slaughterhouses are (4)____ and such meats as are infected with (5)____ are condemned. Pork, however, is not inspected for (6)____, so all pork consumed should be (7)____ (8)____. Stands where foods that spoil easily are sold are (9)____ by (10)____ boards of (11)____, and many communities require that such foods should be (12)____. Cold storage and rapid freezing are used to keep (13)____ foods fresh, but we should remember that such foods do not (14)____ well after cold storage and should be (15)____ at once.

PROBLEM TESTS

Select the answers that will correctly complete the statement.

1. Cattle and other animals are inspected before they are slaughtered for meat because:

(*a*) It would be wrong to kill any sick animals because they should be sent to a hospital until well.
(*b*) They might harbor flies.

(c) They might contain trichina embedded in their flesh.
(d) They might be infected with tuberculosis germs.
(e) They might get germs in the meat after the cattle were killed.

Give your reason for the selection of your answer or answers.

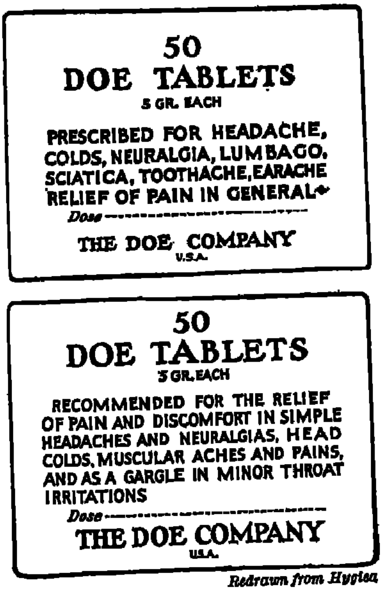
2. Stands containing unprotected fruit and vegetables are a menace to the health of a community because

(a) The dust which gets on them from the street is dirty.
(b) People who come to buy may handle them.
(c) Disease germs might fall on them from an outside source.
(d) Exposure to the air will cause them to spoil more rapidly.
(e) All dirt contains disease germs.

Give your reason for the selection of your answer or answers.

PROBLEM IV. WHAT IS THE FEDERAL FOOD AND DRUGS ACT AND HOW DOES IT WORK?

The Federal Food and Drugs Act. We have already seen that before Congress passed the Federal Food and Drugs Act in 1906 a great many foods were adulterated. This showed the need of protecting people against adulterated foods. It was also known that meats were not always properly killed nor were they properly cared for on the way to the consumer. Then, too, patent medicines were labeled in such a way as to make people think that such medicines could cure diseases when often such a cure was impossible. In other words, they were *mislabeled* and did not tell



Redrawn from Hygeia

What story is told by these two labels?

what substances were contained in the medicine. The Federal Food and Drugs Act has caused the makers of patent medicines at least to label these medicines so that we may know some poisons that are contained in them. While misrepresentations cannot be made by the labels, the law has no control over newspaper and circular advertising. Compare the claims made in advertising with those on the package to see if they agree.

What Is Adulterated Food? The Federal Food and Drugs Act first of all defines what *adulteration* is. It says that adulteration is adding anything to food to cheapen it or to reduce or injure its quality; it is the taking away of any valuable part of food; it is the mixing of colored or stained material with food to conceal damaged or inferior material; it is the addition of poisonous materials or the use of any decayed animal or vegetable substances unfit to eat. Adulteration then is a very large term under this act, which also provides for the punishment of anyone who is detected practicing any of these methods of cheating.

How the Federal Food and Drugs Act Operates. Although Congress doubtless thought it had made good legislation in the case of the Federal Food and Drugs Act, the results are not satisfactory in all respects. The act has prevented the adulteration of foods where the civic authorities are active, but if the board of health of a town or city is not alert, foods kept in bulk may be adulterated by dishonest manufacturers or storekeepers. The act *does* make it necessary for the firm putting up the goods in containers to tell exactly what is in the container. For example, if your grocer keeps cheap jellies, jams, marmalades, or flavoring substances, you may find labels on the bottles or cans stating that artificial coloring, a preservative, and a certain amount of glucose are used. The Federal Food and Drugs Act exercises no control

over the sale of foods and medicines prepared in one state and sold in the *same* state. The law applies only to *interstate* commerce. The state laws apply to preparations manufactured and sold in the state, and some states are very lax in this matter. Cheap candies are usually made of glucose and colored with cheap dyes, and their different flavors are made synthetically out of coal-tar products. There is also cheating at soda fountains where such substitute fruit flavorings are used.

Some Common Adulterations. Many adulterations are met with every day and are not at all harmful. Oleomargarine with coloring matter in it is sometimes unlawfully sold as butter. As a matter of fact, oleomargarine is perfectly wholesome, as are also nut butter, nut oils, cottonseed oil, and other substitutes for butter. Cottonseed oil is frequently an adulterant or substitute for the much more expensive olive oil. Molasses, honey, and maple sirup are often adulterated with glucose or corn sirup. Corn sirup is a good enough food, but it is much cheaper than the materials for which it is substituted and is therefore an adulterant under the law. Cheap grades of condensed milk may have sugar added to them to take the place of foods which were removed from the milk. Coffee, tea, and cocoa are frequently adulterated by the addition of such materials as cornstarch, old tea leaves, chicory, cocoa shells, and other cheap products. Some foods may have adulterants of a harmful nature. We have chemicals used to change the color of meats, such as saltpeter, which brings back the red color to partly decayed meat. There is no doubt that much of the cheaper chopped meat sold in butcher shops is so treated. In the case of flour, alum and other poisonous compounds used to bleach it may be retained. It is said that much of the bread sold today is made with bleached flour, which, while it may not be poisonous,

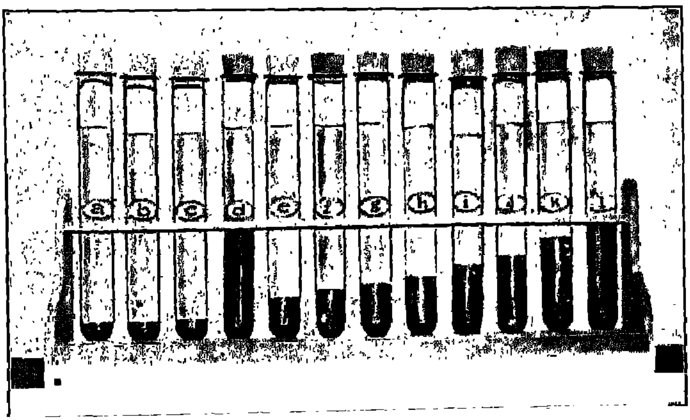
certainly is not improved by the addition of chemicals which bleach it.

Some Harmful Preservatives. But more harmful in some respects is the use of preservatives. Food preserved by means of heat or cold is good food, but if we add chemical substances to it in order to prevent bacteria already in it from causing further decay, then such preservatives become harmful. Many foods contain, under the Federal Food and Drugs Act, small quantities of alum, borax, benzoate of soda, benzoic acid, and certain sulphites. The quantitites used are probably harmless to any one taking a small amount of the substance in question, yet they are not substances we wish to have added to food, as they may mean that such foods may have been close to the point of decay when they were put into the cans or bottles. Other preservatives which are still sometimes used illegally are boric acid, salicylic acid, formaldehyde, and sulphur dioxide, which is allowed as bleaching agent for fruits, but is often found in much greater amounts than the law permits and so might be harmful. It pays to buy a good quality of canned goods and dried fruit, for then we are comparatively safe from harmful preservatives.

Lack of Knowledge Decreases the Effectiveness of the Federal Food and Drugs Act. The Federal Food and Drugs Act permits the use of certain adulterants of foods and drugs, provided the adulterants are plainly named on the label of the container. But the majority of people are not sufficiently educated in these matters to be able to tell what is harmful and what is harmless. The only way for us to know how properly to make use of the Federal Food and Drugs Act is to get some reliable information as to what constitutes harmful preservatives and also what materials are harmful in medicines. Then if we take the trouble to read the labels which the Federal

Food and Drugs Act causes to be placed on the containers, we can sometimes avoid taking poisons into our body. There are, however, many drugs, some of which are poisons, which may be used in "patent medicines" without being named on the label.

Patent Medicines and the Federal Food and Drugs Act. The American people are probably the greatest consumers of "patent medicines" of any people in the world, but we are gradually becoming educated through the working of the Federal Food and Drugs Act to realize that many patent medicines are harmful rather than beneficial. Medicines should not be taken except under the advice of a physician, for the human body is usually capable of curing itself when it is out of order. The chief advantage of the act with reference to patent medicines lies in the fact that the labels on the bottles must not tell untruths, as they have done frequently in the past, because the act prohibits fraudulent statements on the package or bottle. When a medicine is advertised



Amounts of alcohol in some liquors and in some patent medicines. *a*, **beer, 5%;** *b*, **claret, 8%;** *c*, **champagne, 9%;** *d*, **whisky, 50%;** *e*, **well-known sarsaparilla, 18%;** *f*, *g*, *h*, **much-advertised nerve tonics, 20%, 21%, 25%;** *i*, **another sarsaparilla, 27%;** *j*, **a tonic, 28%;** *k*, *l*, **bitters, 37%, 44% alcohol.**

to cure everything, it is evident that it is a fraud. Such labels have been changed to substitute the word "remedy" for the word "cure."

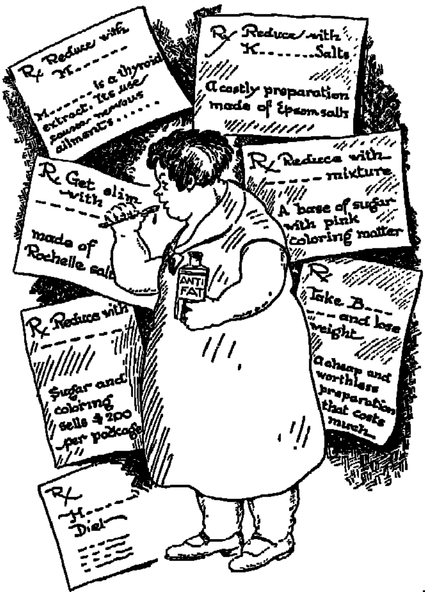
There are eleven drugs which must be declared on the label if present in the medicine. They are: alcohol, morphine, opium, cocaine, heroin, alpha- and beta-eucaine, chloroform, cannabis indica, chloral hydrate, and acetanilid. Other drugs, even some poisons, like arsenic and strychnine, need not be disclosed under the present law. Hence it is not a very good law in its present form and changes are now being planned for it.

Drugs and Their Dangers. Patent medicines might be divided into several groups, according to their composition and uses. The most dangerous of them contain habit-forming drugs. Another type of patent medicine includes the so-called cough sirups which are used to soothe the suffering of people who have tuberculosis. Still another type of drug is said to cure people who have incurable diseases. Such drugs are usually sold to people in the last stages of disease, and most frequently these people are harmed instead of helped. Drugs are dangerous to use except in the hands of expert physicians. Last of all are the medical fakes, "cures" to make thin people fat and fat people thin, instruments to cure deafness, or to bring vitality back to weak or old people.

Dangers from Headache Cures. Most headache cures are harmful and even dangerous. They usually contain phenacetin, acetanilid, chloral, morphine, or some other drug which depresses the heart, causing it to beat more slowly. They also deaden the sensation of pain. Such drugs do not *cure* headaches, and their use simply covers up the real cause of the trouble and makes the user addicted to the drug. Moreover, if a person has a weak heart, these drugs may slow down its action and possibly cause death. No one should use headache remedies with-

out first knowing what they contain nor should they be used except by advice of a physician because headaches are danger signals which show that the body is not working properly.

Habit-Forming Drugs. The basis of many patent medicines used as home remedies is alcohol. Some of these contain over 50 per cent of alcohol. In some parts of the country people have become drunk on patent medicines when they could not obtain liquor. Too often such medicines have been the cause of the formation of a habit of taking alcohol. The person taking the drug containing alcohol feels better temporarily because of the deadening effect of the alcohol and wants more of the same drug. As a result, he soon becomes addicted to the alcohol habit. Other habit-forming drugs contain opium, morphine, or heroin. The users of these may soon become dope fiends.



Most reducing medicines are dangerous to one's health. What should one do to lose weight without endangering one's health?

Medical Fakes. Under such a heading would be placed the so-called *cure-alls* for incurable diseases, such as cancer cures, consumptive cures, the obesity cures, the cures for deafness and epilepsy, and many others. Many of these are pure and simple fakes. Cures for over-fatness, for example, have been found to be made

of such materials as cream of tartar and baking soda, sweetened and colored pink. It is perfectly plain that such materials would not make a fat person thin. Tuberculosis can be cured only by treatment and not by drugs. Cancer is curable only in its early stages, and, so far as known, not by drugs at all.

False Use of Testimonials. One bad feature of the patent medicine industry is the use of the testimonial. People who take a drug often think they are cured by it when their pain is only deadened. So they write a testimonial to the company saying they are cured, and it is printed far and wide in advertisements of the medicine. It has sometimes happened that such a statement appears in the same paper that contains a notice of the writer's funeral.

How to Make This Problem Benefit Us. We have already said that the chief reason why the Federal Food and Drugs Act is ineffective is because people do not have sufficient knowledge to understand it. Those of us who have been fortunate enough to learn something of its applications can easily learn more by working up a project on some interesting phase of this unit. The American Medical Association has published many pamphlets on medical frauds which will suggest material for several interesting reports before the class. Learn if you can, from your druggist or physician, other prepared medicines which contain harmful or poisonous drugs not indicated by the label. It is only by enlightening many people that we can finally create public sentiment which will result in new laws which will better protect the people of this country against harmful drugs.

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

within	inside	state	country
partially	entirely	cures	adulteration
patent	medicine	harmless	harmful
statements	protects	drugs	deadly
newspapers	poisons	between	magazines
outside	cosmetics	alcohol	glucose

The Federal Food and Drugs Act is not a perfect law because it only (1)____ (2)____ us against the evils it is supposed to cure. It says that the labels must tell the truth about (3)____ and must name certain (4)____ (5)____ used in the composition of (6)____ medicines. But it does not mention a number of (7)____ (8)____ which may still be used, nor does it prevent (9)____ or (10)____ from making false (11)____ concerning medical fakes and frauds. In addition the law only works (12)____ states, for almost any adulteration may be made and sold (13)____ a given state if it is not sold (14)____ that (15)____ and still be within the law.

PROBLEM TEST

John does not feel well; he does not know what is causing his illness, but he wants to get well quickly so that he can take part in a coming track meet. What should he do?

Check the following statement or statements that best answer the question.

He should follow the advice of a friend and take some medicine which will act as a tonic.
He should not do anything.
He should see his family physician and follow his advice.

Check the following reasons for your answer or answers.

His friend was helped by taking ____'s Bitters, so he should also.
He will get well eventually, so why worry.
His family physician is a good friend and needs to make a living.
A physician is trained to recognize symptoms of disease and therefore should be able to help him to get well.

PROBLEM V. ARE TOBACCO AND ALCOHOL REALLY HARMFUL?

What Is the Truth about Stimulants and Narcotics? We hear a good deal nowadays about the dangers from alcohol, especially in this age of automobiles, and old people, although they may smoke themselves, are constantly advising young people not to use tobacco.

As members of the science class, let us apply the method of science to this question, and see, first of all, what these substances are and then find out what they do to the human body.

What Are Stimulants? In our study of patent medicines, we have seen the words "stimulant" and "narcotic" used. What are these substances? We have already learned that food is everything which gives energy to the body or helps to build it up. Other substances that we take into the body, such as tea or coffee, are not taken as foods, but as mild stimulants or bracers. They act on the nervous system, causing a feeling of mental exhilaration. They brace us for a time by their stimulating effect, but when this effect wears off, they leave us more tired than before. They are also habit forming. A person can become a coffee or tea addict just as he can become a drug addict. While tea or coffee rarely does much harm to adults if used in moderation, we often find that they are harmful to younger people, especially if taken strong.

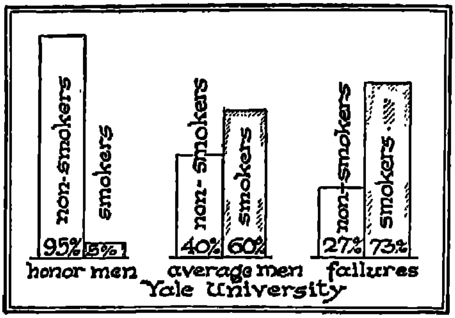
Narcotics Are Dangerous. Of far more danger are the drugs we call *narcotics*. A narcotic is a substance which "blunts the senses, directly induces sleep, and in large amounts produces complete insensibility." This, you say, does not agree with anything you are familiar with. But many of you have known of the experience of boys or girls who smoke for the first time. They become pale, giddy, and sick at the stomach. This indicates the effect of a poison in the tobacco known as nicotine. Pure nicotine is a deadly poison, as those of us know who have used it to spray rosebushes to kill off the aphids on them. Put just one drop of black leaf 40 (a nicotine poison) into a jar of water containing a small live fish and see what happens. Since tobacco leaves contain from 2 per cent to 9 per cent of this poison, it is easy to see

why the first effect of smoking is so unpleasant. Unfortunately smoking also becomes a habit. Like some other narcotic drugs, it has at first a slight stimulating effect, and as the system becomes accustomed to the drug, we get a craving for the drug which is difficult to break, as those who have tried to break off smoking can testify.

If you can kill insects with nicotine, why use it on yourself?

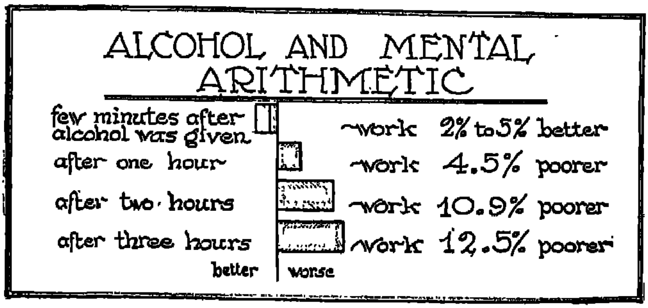
Some Reasons for Not Smoking. Smoking for young people has little to recommend it and a good deal against it. It is an expensive habit, for you simply burn up money. It does harm to most people, some get a "tobacco heart," others a "smoker's throat," and still others may develop severe indigestion. Athletes are discouraged from smoking by coaches who have seen too many races lost by shortness of wind. Two colleges, at least, have found that students who do not use tobacco have gained in weight, height, lung capacity, and size of chest over the smokers in those colleges. Tobacco apparently is a handicap, so why get the smoking habit?

Alcohol a Narcotic Poison. Of far more danger than nicotine is alcohol because of its effects on the nervous system.



What do you think these figures mean?

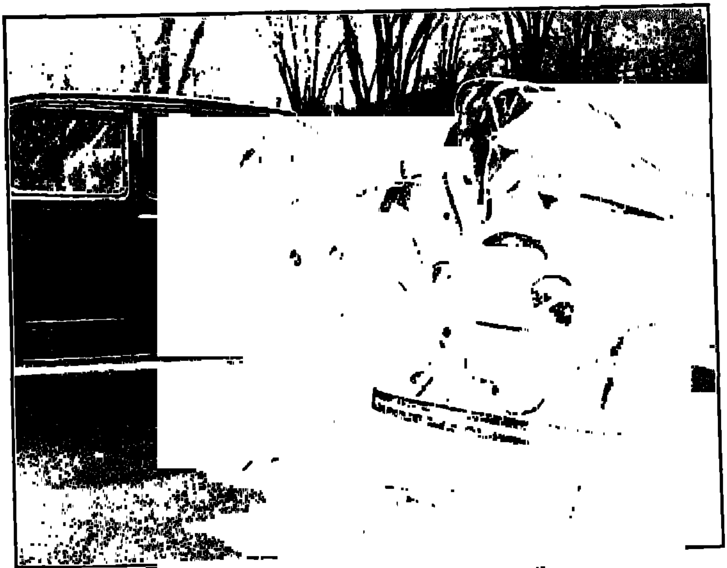
Alcohol used to be considered a stimulant because people who took it thought they felt stimulated by a drink or two. But what really happens, as we know now, is that the nervous system is deadened a little so that our judgment and good sense are lost for the time being. This is where the danger comes. A great many experiments have been made with people who were given small quantities of alcohol on one day and none on another day, and were given mental work requiring concentration and attention. There was always a loss in attention on the alcohol days. An experimenter in Switzerland gave a group of ten pupils a very small amount of alcohol each day and compared their work in mental arithmetic with another group of like ability which was not given any alcohol. The work of the alcohol group for the first few minutes was from 2 per cent to 5 per cent better, but after one hour their work was 4.5 per cent poorer, after two hours 10.9 per cent poorer,



Most experiments like this give similar results.

and after three hours they were 12.5 per cent behind the other group. Still another experiment showed that as little as $\frac{2}{3}$ of a tablespoonful of alcohol decreased clearness of vision. Experiments also show slower reactions to stimuli and loss of muscular co-ordination.

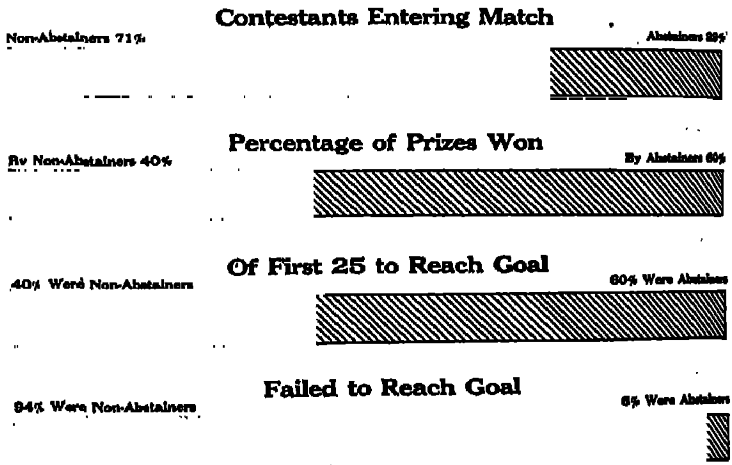
Alcohol and the Car. All these experiments point to a reason for the increasing toll of automobile accidents since the repeal of the eighteenth amendment. Driving an auto requires concentration, clearness of judgment, and quickness of decision. All these are natural to young people. They react much quicker than do older people and as a rule make better drivers than their elders. But if befuddled and slowed down by the narcotic action of alcohol, they lose this control they would normally have, with the result that more accidents occur now than did a few years ago. As one writer says, "The margin between safe driving and unsafe driving is too narrow



Alcohol and safe driving do not go together.

to permit drinking." In England one of the rules in a safety pledge now being circulated reads: "To drive only when in full possession of my faculties." As one physician has well said, "Those of us who are motorists know how much safer roads are when they are dry. We want to put it to you, how much safer the roads will be when drivers are dry too."

Alcohol and Athletics. Boys and girls who are interested in athletics know that alcohol and athletics do not go well together. Coach Knute Rockne, as director of athletics in Notre Dame University, absolutely prohibited the use of alcohol to the players of his teams. And you remember that his football teams had a record of 70 games won, 6 lost, and 2 tied up to the time of his death. Another much-loved coach is A. A. Stagg. He says: "As a coach I do not believe, and none of the coaches who train men believe, in the use of alcoholic beverages." Helen Wills says that in playing tennis, one glass of beer is enough to make a difference in one's eye, co-ordination, and balance. Nurmi, the great



What do you learn from a study of these graphs?

distance runner, never took alcohol before his first visit to America and was a winner. But after that first visit he began to drink in moderation, and soon began to be defeated. Tilden, Tunney, Jack Dempsey, Annette Kellerman, and scores of other athletes have added their testimony on the harm of drinking in athletics.

Alcohol and Health. Young people are not much interested in the question of long life or old age, but it is worth looking into a few facts about what alcohol may do to the body organs. It may take a long time to ruin a good machine, but sooner or later the human machine will break down under the influence of alcohol. It irritates the digestive organs and may cause a disease known as liver *cirrhosis*. It hardens the arteries before their time and weakens the heart. It breaks down the natural resistance of the body against infectious diseases and greatly increases the danger from accidents, and it damages nervous tissue so that insanity or other nervous diseases may result. And worst of all, it seems to affect the children born of alcoholic parents so that they come into the world handicapped.

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

insensibility	stronger	stimulates	tobacco
wine	time	beer	tired
9 per cent	8 per cent	senses	stimulants
help	well-being	alcohol	vegetable
coffee	narcotic	whisky	mineral
whip	sleep	4 per cent	weaker

A stimulant gives one a feeling of (1)____ and makes him feel (2)____ for a (3)____ but soon acts as a (4)____ to a (5)____ horse. We cannot run long on (6)____. Tea and (7)____ are both mild stimulants. A narcotic induces (8)____, blunts the (9)____, and in large amounts produces complete (10)____. Nicotine, found

in (11)____ in amounts varying from 2 per cent to (12)____ and (13)____, found in beer, wine, and distilled liquors, are both (14)____ poisons.

ESSAY TEST

Jack Gives Advice to Athletes

Read carefully and critically. List all the errors and suggest corrections.

After reading the problem and looking up the subject of alcohol and narcotics, I am sure that two things athletes need to leave alone are tobacco and narcotics. I can't remember all the experiments quoted, but I know from my own experience that you can't run and smoke cigarettes. They certainly spoil your wind and make you dizzy. It gave me a "smoker's cough" but did not spoil my chances to win the 100 yard dash last spring.

As for alcohol, I haven't had any experience with that, but from what the coaches say, I think it's about the last thing an athlete should fool with. I think a lot of A. A. Stagg, the ex-Chicago coach. If he and Knute Rockne forbid any alcohol to members of their teams, I guess that is reason enough for me to leave it alone. No self-respecting sport would take anything that would make him a liability instead of an asset to his school team.

THE REVIEW SUMMARY

In preparing a summary of what you have found out in this unit, you will want to place emphasis on the big ideas which have come from the applications of the facts you have learned and the demonstrations you have seen. Doubtless you have done some additional reading which has helped you put together some of the facts into generalizations or fundamental underlying principles. For this unit some of these generalizations are:

1. Public food supplies need to be protected because they may spread disease.
2. Milk, our best food, needs especial care in handling.
3. Disease carriers are a menace to health.
4. The Federal Food and Drugs Act protects us but should be improved.

5. More education is needed with reference to the harmfulness of patent medicines and alcohol.

Before making your review summary for your workbook, test your knowledge of the facts of the unit by checking over the text so as to be sure you know the facts underlying the science principles or generalizations. Then using this material and everything you have read, seen, or done yourself, make your summary outline. This outline you may use when you make a recitation.

TEST ON FUNDAMENTAL CONCEPTS

In a vertical column under the heading CORRECT *write numbers of all statements you believe are true. In another column under* INCORRECT *write numbers of the false statements. Your grade = right answers* $\times 2\frac{1}{2}$.

I. **Food supplies should be protected because:** (1) they are good to eat; (2) epidemics are often spread through infected foods; (3) disease germs are present almost everywhere; (4) handlers are often carriers of disease.

II. **Epidemics of infectious diseases:** (5) are sometimes caused by eating well-cooked fruit; (6) may be spread by carriers; (7) might be spread by means of dirty raw vegetables; (8) might be caused by spraying fruits or vegetables with poisons.

III. **Epidemics may be prevented by:** (9) safeguarding milk, water, and other food supplies from harmful germs; (10) not eating anything except cooked foods, for they do not contain germs; (11) exercising each day in the open air so as to keep the bodily resistance high; (12) making laws that protect us.

IV. **Carriers are a menace because:** (13) we do not always know them and so they may spread disease without meaning to do so; (14) no laws adequately protect us from them; (15) they carry disease germs; (16) they are always sick.

V. **Milk:** (17) is always pure when it comes from the cow; (18) will not sour if it is pasteurized; (19) never contains disease germs, as these are always introduced from the outside; (20) is dangerous if it comes from dirty cows.

VI. **Food supplies may be protected:** (21) by keeping perishable foods in cold storage; (22) by covering fresh fruits, vegetables, etc., from dust and flies; (23) by having an efficient food inspection; (24) by floating oysters in dilute sewage.

VII. **Harmful germs may be prevented from entering the body:** (25) by drinking six glasses of water every day; (26) by having regular hours for going to the toilet; (27) by exercising regularly

each day in the open air; (28) by taking care to keep the fingers out of the mouth.

VIII. The Federal Food and Drugs Act is valuable because: (29) it defines adulteration; (30) it provides for the inspection of food supplies; (31) it keeps down the price of canned goods by allowing harmless adulterants to be used; (32) it requires foods containing adulterants or coloring matter to be so labeled.

IX. It is the place of the community to protect the health of its citizens by: (33) having supervision over common supplies such as milk and water; (34) requiring all sick people to consult the city physician; (35) having high taxes in order to have up-to-date street cleaning and garbage disposal; (36) having an efficient board of health.

X. Patent medicines: (37) are often harmful because they contain habit-forming drugs; (38) often contain poisons not mentioned on the label; (39) can always be used with safety if one reads the label carefully; (40) always contain alcohol.

PRACTICAL PROBLEMS

1. Constance has a bad cough which has "hung on" for several weeks. She goes to her local druggist for help. He tells her to try a bottle of Dr. Fakem's Cough Cure, which contains 20 per cent alcohol and several habit-forming drugs. What should the druggist have done, and what should Constance have done in the first place? Why?

2. Mary is fifteen pounds underweight. What should she do to gain her normal weight?

3. Clara weighs ten pounds more than normal and wants to use Madam Slimjim's Reducer. Should she do this? Can you make suggestions for her daily life and for her dietary?

INTERESTING THINGS TO DO, READ ABOUT, OR SEE

1. If you live in a community that is near the coast, try to find out all the ways in which you are protected from shellfish which might be unfit to eat.

2. Go to the board of health and make a graph or get material which will aid you in making a graph to show the outbreak of an epidemic in your own community.

3. Look up the Federal Food and Drugs Act and make a report on it for the science class.

4. See how many school coaches you can interview so as to get their opinions on the use of tobacco and alcohol by athletes.

5. Inspect a local dairy, using the score card given below.

CITY MILK DEPOT SCORE CARD

Equipment	Score	Methods	Score
No barn within 500 ft.	2.5	Clean yard	2.5
No open privies within 500 ft.	2.5	Clean utensils	5
Locality insanitary—deduct 2.5	0	Clean floor	1
Separate building	5	Clean windows	1
Part of residence	2.5	Clean walls	.5
Grocery dairy	1	Clean ceiling	.5
Cellar dairy	0	Flies, none	5
No other business done	2.5	few	1.5
Salesroom separate	.5	swarms . . . deduct 10	0
Floor, cement	2.5	Utensils	
tight boards	1	sterilized in autoclave	5
dirt	0	sterilized by steam	3
Walls cemented or painted	1.5	sterilized tank hot water	2
whitewashed	1	scrubbed	1.5
papered	.5	only rinsed	.5
Lighting good	1	Milk kept covered	2.5
natural or electricity	.5	pasteurized in bulk	1
gas	0	pasteurized in bottles	2.5
Ventilation good	5	Kept 45° F. or below	5
Screens good	2.5	45° F. to 50°	1.5
broken	1	50° to 60°	.5
none	0	60° to 70° . . deduct 5	0
Machinery:		above 70° . . . deduct 10	0
bottler and can washer	2	delivered ice cold	5
milk cooler	5	thermometer used	2.5
bottling machine	1.5	cooler kept covered	1.5
capping machine	.5	Men clean, healthy	2.5
pasteurizer	2.5	sterilized duck suits	1
cold-storage plant	2.5	clean dustless clothes	1
autoclave	5	hands clean	5
Water, purity known	2	no spitting on floor	2
Wash basin provided	1.5		
Individual towels	.5	Total score (maximum 50)	. . .
Total score (maximum 50)	. . .		

Full credits given, or none

How high does your dairy score? It should rate over 40 to be fair.

6. Try to find out what the laws are in your own community and state with reference to pasteurization of milk. Does your state have as good a record as Massachusetts?

7. Make a collection of Health Posters and place them on the science bulletin board for exhibition.

8. If you are interested in art, make a good poster for your bulletin board.

9. Prepare or collect and exhibit on the bulletin board a number of poster slogans as: "Beware of the little White Slaver"; "Alcohol makes hard work harder"; "Dr. Fixem's pills will fix you for keeps," or any that you can supply.

10. Using the table below, make a survey of several stores in your locality to see how near to the ideal these stores are. Make the report for your workbook. Do not use names — call them store A, B, C, etc.

5. CARE OF FOODS IN A STORE

Kept Closed under Glass	Shielded from Flies, Dust, and Hands	In the Refrigerator	Elevated 12 Inches above Floor	May Be Kept on Floor
bread	berries	butter	artichoke	canned goods
cakes	celery	cottage cheese	cabbages	carrots
candy	cherries	cream	cantaloupe	cucumbers
cheese	dates	dried currants	cauliflower	nuts (whole)
crackers	figs	eggs	cranberries	onions
dried fruits	grapes	fresh fish	grapefruit	peas
dried meats	lettuce	fresh meats	lemons	potatoes
opened fruits	peaches	milk	oranges	pumpkins
pastry	pears	mincemeat (fresh)	pickled food	squash
shelled nuts	plums	oysters	spinach	turnips
watermelon (cut)	prunes		string beans	watermelon
	radishes			
	raisins			

11. Using the list of foods given above, report on the conditions in the stores that you patronize. How many of the above foods are properly cared for?

12. What are the food and drugs laws in your state? Are they well enforced? Make a report to the class on your findings.

13. Find out from your druggist what poisonous drugs may be put into patent medicines without the public being the wiser. Look up in the reference given at the end of the unit for information on this subject.

14. Study the labels of patent medicines in a drug store. What diseases do they claim to cure? Ask your family physician about their claims. Collect newspaper advertisements of medicines and compare the claims made in these advertisements with those on the labels. Look through current copies of the magazine "Hygeia" for articles on patent medicines.

15. Score up your community, or at least that part in which you live, with reference to the points suggested in the score card on the community care of food which is given on the opposite page.

SCORE CARD. COMMUNITY CARE OF FOOD

		Total Score	My Score
MILK INSPECTION	Milk inspected at farm where produced (2) Milk inspected in transit to city (2) Milk inspected in bottling establishment (2) Milk inspected at point of sale (2) Tubercular tested cows furnish all of supply (8) Laws with reference to typhoid carriers enforced (5) Grading of milk sold based on standard of American Medical Association and sold as graded; all milk below grade "A" pasteurized; no dipped milk sold (9)	30	
FOOD INSPECTION	Regular inspection of slaughterhouses and meats (5) Regular inspection of cold-storage plants (2) No cold-storage goods unfit for public use sold (3) All bakeries regularly inspected (3) Modern baking plant in community (1) Foods in store kept according to schedule (3) All foods on push-carts covered (3) Butcher shops inspected regularly and free from flies and offal (5) Shellfish and fish supplies safeguarded and inspected (5) All persons handling foods free from disease, restaurants clean and inviting (5) Soda fountains, individual and sanitary drinking cups (5) Regular inspection of weights and measures (5)	45	
PURE FOOD AND DRUGS ACT	No adulterated candy sold (5), some (2), much (0) No medical fakes sold (10), some (4), many (0) No headache cures sold without prescription (10), some (4), many (0)	25	
	TOTAL	100	

16. Investigate the subject of pure foods in your community and report to the class.

17. Make a study of the "patent medicine" situation in your community.

18. Look up the subject "Nostrums and Quackery" and give a report in class upon several specific items.

SCIENCE FOR LEISURE TIME

1. Experiment. To Test Jelly, Jam, or Ice Cream for Glucose and Starch

Materials. Samples to be tested, test tubes, Fehling's solution,[1] iodine solution, funnel, and filter paper.

Method. Add a teaspoonful of the sample to a test tube half full of water and heat. Filter. To one half the filtrate add 5 c.c. Fehling's solution and boil. A red precipitate indicates the presence of glucose. To the remainder of the filtrate add a drop or two of iodine solution. A blue or blue-black color indicates starch.

Result. Do any of the foods tested contain glucose or starch?

2. Experiment. To Test Cheap Candies and Jam for Artificial Coloring

Materials. Brightly colored candies, cheap jams, evaporating dish, white woolen yarn.

Method. Mix a tablespoonful of jam or a piece of colored candy in an evaporating dish half full of boiling water. Put into this a piece of white woolen yarn and boil for ten minutes. Then remove and wash the yarn in hot water. A bright color left on the yarn indicates artificial dyes.

Result. What substances tested were colored with artificial dyes?

3. Exhibit of Colors from Candies and Jams

Make various pieces of clothing for a small doll out of white silk and white wool. Dye each separate piece a different color. Obtain colors from bright-colored cheap candies, jams, and coloring for oleomargarine. Mix the material — jam or candy — with a small quantity of water and bring to the boiling point. Stop boiling and put in the cloth. Stir it and keep it hot for 10 minutes. Then rinse in warm water and dry. If you make different colors for skirt, waist, hat, stockings, and shoes, you will have a very interesting exhibit to show your friends.

4. False Claims for Patent Medicines

Make a collection of newspaper and circular advertisements of patent medicines. Collect from your friends labels taken from patent medicine bottles. Match up advertisements and label for the same medicine as far as possible. Are the same claims made on both? If not, can you explain why? Which makes the stronger claim, the advertisement or the label?

[1] Fehling's solution, made by dissolving 6.2 gm. copper sulphate, 3.5 gm. Rochelle salts, and 2 gm. potassium hydroxide in 100 c.c. of water.

SCIENCE CLUB ACTIVITIES

1. Stage a debate. Resolved: That the Government should cease to exercise control over foods and drugs sent from one state to another, but leave to each state the entire control of foods and drugs within that state.

2. Visit a market garden in your locality and report to the club on the methods used in fertilizing, watering, picking, and marketing the vegetables.

3. If possible, have members of the club score several different dairies with the card found on page 397, and then get some member of the board of health to discuss your findings with you.

4. Plan and carry out a sanitary survey by as large a number of club members as possible. Make a map of the block or part of the town in which you live. Show all the buildings, stores, factories, etc. Indicate any cases of communicable disease with a Q (quarantine). Indicate all heaps of refuse, all uncovered garbage pails, any street stands or push carts which sell uncovered fruit, and any unsanitary stores. What is your opinion of sanitary conditions in your immediate environment? A sanitary survey of this sort made by a large number of students may be of great value, as it will show that some parts of a city are well protected and others are not.

5. Visit a local slaughterhouse and find out to what extent your locality is protected against bad meat.

6. Study the labels of jellies, jams, preserves, etc., and note those which use artificial coloring, preservatives, or glucose. What per cent of the total of canned foods observed show adulteration as defined by the Federal Food and Drugs Act? Make this a club activity, using as many different stores as possible. Make a summary for a chart to be put on the bulletin board. Do not use names of stores, but designate them as store A, B, C, etc.

REFERENCE READING

Broadhurst, J., *Home and Community Hygiene.* Lippincott Co., 1925. Milk, water, and food in relation to health, pages 18–115.

Cramp, Arthur J., *Nostrums and Quackery.* American Medical Association, 1921. Vol. I. Cancer cures, pages 25–68; consumption cures, pages 76–183; fakes, pages 295–315; cure-alls, pages 436–453; headache cures, pages 494–512. Vol. II. Consumption cures, pages 18–55; cough medicines, pages 109–136; nostrums, pages 482–633.

Fisher, I., and Fisk, E. L., *How to Live.* Funk & Wagnalls Co., 1925. Entire book.

Kallet, A., and Schlink, F. J., *100,000,000 Guinea Pigs.* Vanguard Press, 1933. Chapters II, III, IV, XIII, XIV.

Survey Questions

How many superstitions do you know about disease?

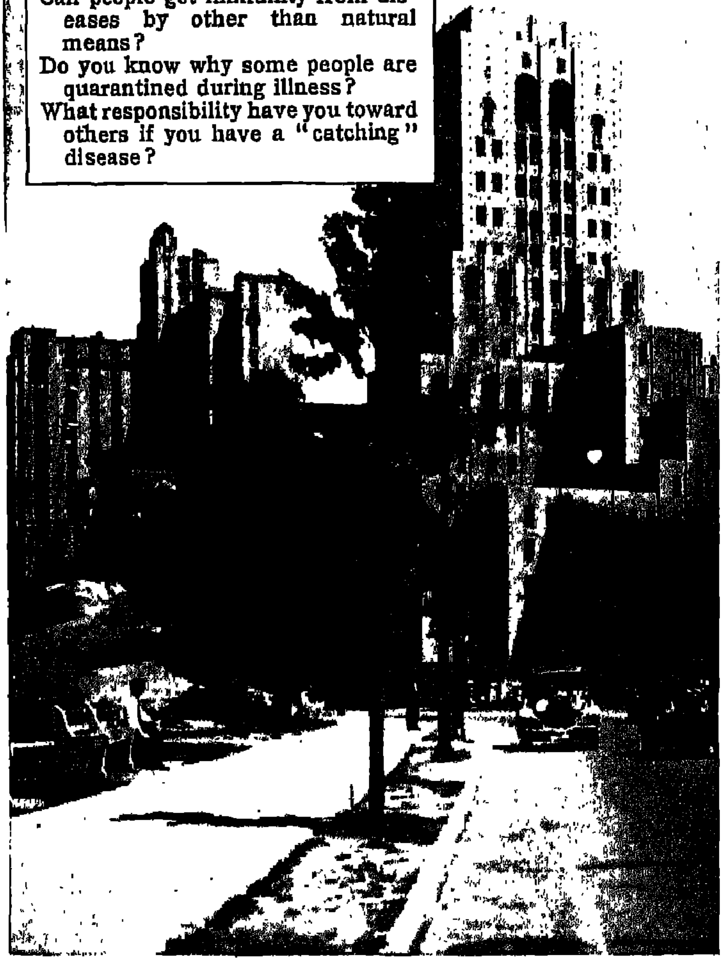
Do you believe everything you read about the value of patent medicine?

Do you know what it means to be immune from a disease?

Can people get immunity from diseases by other than natural means?

Do you know why some people are quarantined during illness?

What responsibility have you toward others if you have a "catching" disease?



Galloway

UNIT XIV

HOW THE COMMUNITY LOOKS AFTER THE HEALTH OF ITS CITIZENS

PREVIEW

The word *disease* means not having ease. It is opposed to the word *health*, which comes from an old English word meaning whole and sound. There are several groups of diseases. Probably one half of the deaths of the world are brought about by diseases which are caused by bacteria. Many of these deaths, with knowledge and care, could have been prevented. Many deaths result from industrial poisons, such as arsenic, mercury, and lead. Still others come from lack of proper foods, and are called deficiency diseases. There are a great number of old people who die from the breakdown of various parts of the body. The heart or arteries are overstrained, become weak, and finally can no longer function. Other body organs do the same; these are degenerative diseases. Then there are some diseases of unknown origin. The worst enemy of the latter type at present is cancer.

Our knowledge of the cause of diseases and the scientific methods of fighting them are comparatively recent. The days of the witch doctor are over in most parts of the world, although some tribes and some backward communities still have their medicine men. It was not so many years ago that doctors used incantations over their patients, gave them medicines made from herbs, or tried to get rid of disease by bleeding the patient. The death of Washington was hastened by the process of

blood letting. Chinese doctors today sell dried turtles, toads, and other animals to the believing public. The patent medicines of today rely largely on mystery for their effectiveness.

Devil dancers of Tibet. Such dancers are supposed to frighten away evil spirits.

A knowledge of what science is doing to prevent disease should be learned and used in our daily lives. Why is so much money spent for hospitals, in research laboratories, and by organizations such as the Rockefeller Foundation? Why do we fight flies and mosquitoes? Why do we protect our water and foods? This unit will aid us in finding out some of these things.

The doctors of the future will show us how to keep well rather than how to get well after having a disease. Our present-day knowledge is so much greater than it was a few decades ago that now we know what to do for most of the common forms of illness, and, what is more important, we know how to keep from getting ill. The trouble is that many of us, as individuals, will not act according to the knowledge we now have. People are careless of their own health and still more careless of the health of others. They have diseases that are catching, and yet they are not willing to give up their freedom in order to protect other people from getting the disease. Some of us want to know about disease or about our own physical defects when they are pointed out to

us, and some in this enlightened age still disbelieve the presence of germs and the harm that they do. To keep well, two things are necessary: first, we should have enough knowledge about disease to avoid unnecessary exposure to contagious diseases; and secondly, we should be willing to make the matter of personal health of so much importance that we will take the time and use the money necessary to keep well. We should know ourselves. We should be willing to go to our family physician and learn of the various tests and other means by which we can protect ourselves against infectious[1] diseases. Our teachers, in the study of certain units in this book, will help us with reference to matters of weight, diet, and daily health habits.

Do you have a yearly health examination in your school? What is the doctor doing? Of what value might such an examination be?

Before you begin a serious study of this unit, think back and see what science principles and big ideas you can recollect from last year's science work. You may

[1] infectious (ĭn-fĕk'shŭs): catching, communicable, germ disease.

remember that we studied about the human machine and how to care for it. There were a few very important things learned then that will be most useful to build on now as a foundation of science. These are the following:

Science Principles

1. The human body is built up of cells, tiny units of living matter.
2. Work is done in the cells.
3. The body grows by increases in the number of cells.
4. The skin protects the body cells and is a heat-regulating organ.
5. Movement is brought about by the interaction of muscles and bones.
6. Digestion makes food soluble so that it can be used by the cells.
7. The nervous system controls the body.

You may think of others, but these above are directly concerned with the contents of this unit.

PROBLEM I. WHY SHOULD THE COMMUNITY LOOK AFTER OUR HEALTH?

Some Reasons Why People Need Protection. Scientists know that owing to bad working of an inadequate Food and Drugs Act, the propaganda of advertising, and the fact that most people are naturally careless about what they put into their stomachs, many people die before they should and a much larger number are made to suffer from ailments which could easily be avoided. There is no doubt that people are careless about foods, drinks, and drugs. Much of this carelessness is due to a belief that if an advertisement states something about a food or a tooth paste or a patent medicine it states the truth. Unfortunately this is not so, for there is no law

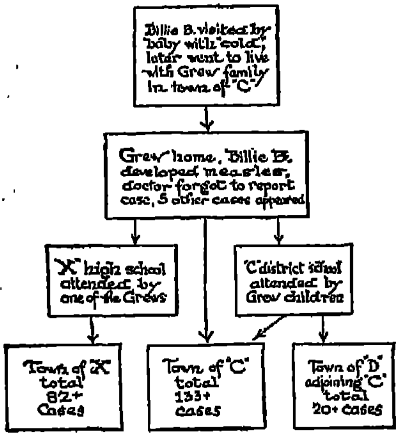
Do *you* believe everything you read?

to prevent the most fraudulent kind of propaganda getting into advertisements. People are credulous and believe what they see in print. One thing our science should do for us is to make us realize that unless we know the facts and can get them from reliable sources or by experiment we should be suspicious of printed statements we see in advertisements.

We Need Protection against Ourselves. But we not only need to be protected against our ignorance and credulity, we also need to be protected against ourselves. Some savages still have their medicine men and believe in them. Civilized people do not have medicine men, but they worship instead the patent medicine. When we realize the amount of money that is spent annually on really harmful medicines, mouth washes, hair restorers or removers, skin bleaches, and the many other devices of the patent medicine industry, we can realize how much we need new laws that will better control the sale and use of harmful drugs.

We Are Superstitious instead of Scientific. Recent studies of high school boys and girls have shown that with all the opportunities they have had for learning

the truth very many of them still have superstitions. Some of them believe in hunches, in the rabbit's foot, or in touching wood. They won't sit down thirteen at a table or pass under a ladder. They still believe that horsehairs turn into snakes and that toads give us warts. When it comes to the matter of health knowledge, they show equal lack of thinking. They do not stay away from companions who have contagious diseases because they do not believe in germs, or they will take a chance on catching the disease because "after all, you've got to have it sometime." Such people are as bad as those who are superstitious.

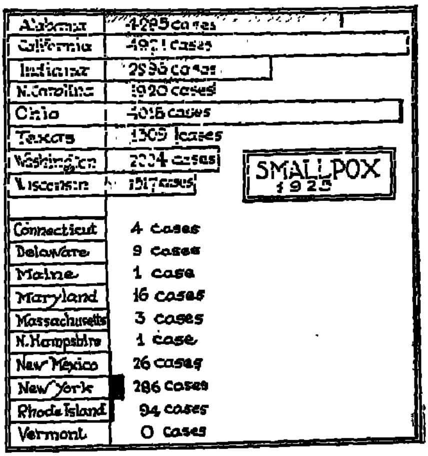


What resulted from the failure of this doctor to quarantine Billie's case of measles?

We Are Selfish instead of Co-operative. But in another way we need to be controlled. Everybody is more or less selfish. We do not always consider the other fellow. Which is easier, to allow Willie to go to school when he has a bad cold or to keep him at home until he is well, thus preventing other children from taking that cold? Or let us be personal. Suppose you have a slight cold and a headache. You want to go to school for you do not feel really sick. You go to school, and later come down with the measles. Think how many of your classmates were exposed to this disease and how many days of school absence you may have caused. Perhaps some of your best friends may have caught the disease and become very sick. No, we cannot afford

to be selfish and we ought always to submit cheerfully to any quarantine imposed upon us for the sake of the other fellow. Here is where the community needs to step in. If a person is too selfish or too ignorant to obey quarantine laws, then the community has a right to protect the other citizens from his carelessness. If, for example, a person does not believe in vaccination against smallpox and has the disease, then the community has a right to isolate this person from others to whom he might give the disease.

Some Facts about Smallpox. That such people exist today is proved by the figures on smallpox in the United States. Some states are rigid in their use of vaccination against smallpox and others do not have such strict laws. Such states are, for example, New Jersey, which has laws which require the vaccination of school children, and California, which does not have such a practice. During a period from 1924 to 1928 the average rate of smallpox per 100,000 in children from 10 to 14 years was 3.6 in New Jersey, while in California during the same period for the same age group it varied from 376.3 to 44.5 per 100,000. Or take some other statistics. In 1931 the prevailing smallpox rate was less than .5 per 100,000 in Massachusetts and New Jersey, states having good laws regarding vaccination, and there were



In which states was vaccination enforced?

133 and 107 per 100,000 in Kansas and South Dakota, states which did not take such care of their citizens. In 1931, although there were only 26,004 cases of smallpox reported from 43 states, 86 per cent of these cases came from a group of 19 states situated chiefly in the north central and western parts of the country. This same story might be repeated for other contagious diseases and shows that a community or state which takes proper care of its citizens through the enforcement of laws which require the early reporting of contagious diseases, quarantine and vaccination or inoculation against disease will reduce the amount of disease. Public health may be purchased, but only by co-operation of citizens, young as well as old, with the health authorities. Just how we protect ourselves from disease will be shown in the problems which follow.

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

contagious	disease	superstitious	surgery
selfish	unselfish	laws	advertisements
patent	good	health	vaccination
drugs	untrue	scientific	harmful
rights	medicines	protection	religious
quarantine	useful	truth	doctors

Many people believe everything they read in (1)____ about (2)____ (3)____ and nostrums, but such statements are often (4)____ or tell only part of the (5)____. As a nation we spend much money on (6)____ (7)____ and cosmetics. People are also (8)____ and fail to recognize the value of scientific knowledge in combating (9)____. As a rule people are also (10)____ and fail to consider the (11)____ of others when they do not observe (12)____ in cases of contagious disease. We need better (13)____ and more adequate (14)____ against the ignorant or ill-informed persons who do not believe that (15)____ diseases may be combated by modern methods such as (16)____ against smallpox.

PROBLEM TEST

Smallpox is found everywhere and is not dependent upon climate, soil, sanitary conditions, or races of people. Account for the following figures taken from health statistics for the year 1931.

Smallpox showed the following average in the states mentioned below for the year 1931.

Arkansas		40	cases per 100,000
California		25	cases per 100,000
Kansas		133	cases per 100,000
Maine	Less than	.5	case per 100,000
Massachusetts	Less than	.5	case per 100,000
New Hampshire		1	case per 100,000
Pennsylvania	Less than	.5	case per 100,000
South Dakota		107	cases per 100,000
Vermont		90	cases per 100,000

Check the statement or statements below that best explain the variations listed above.

1. The climate of the state caused the difference.
2. Some states had more whites than others and whites are more susceptible.
3. Vaccination laws were better made and better kept in certain states.
4. Sanitary conditions were better in certain states.
5. There were fewer people who were *naturally* susceptible to smallpox in certain states.

PROBLEM II. HOW ARE INFECTIOUS DISEASES SPREAD?

Demonstration 1. How Germs Are Spread.

Use six sterile Petri dishes containing culture media. Open one at a time. Let a fly walk on the surface of one dish. Have a student cough in another; put your finger in your mouth and then touch it to the surface of a third dish; touch the surface of a fourth dish with a used moist handkerchief; touch the surface of a fifth dish with a fork or spoon that has been used; leave one dish unexposed as a control. Replace all covers immediately and place the dishes in a warm place for two days. Give results. What are your conclusions?

Demonstration 2. To Discover the Distance Germs May Be Scattered by the Droplet Method of Infection.

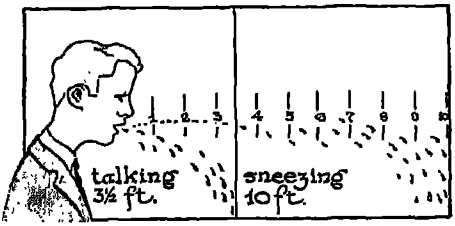
Materials. Five Petri dishes with sterile agar.

Method. Cough into one dish of agar at a distance of two feet, into a second at three feet, and into the third at five feet. Hold a fourth dish two feet away and cough into a clean handkerchief. Use fifth dish as control. Cover the dishes and leave them in a warm dark place for several days. Examine them to see which has developed the greater number of colonies of bacteria.

Result and Conclusion. What is the result in each case? What dangers are there from the "coughs" of people having colds and throat diseases?

Application. How can the spread of disease by coughing be greatly reduced?

Some of the Ways in Which Infectious Diseases Are Spread. The germs causing infectious diseases enter the body through some body opening, usually the mouth or nose. They may be passed from one person to another by means of direct contact, as in kissing, through the mouth spray, or through the agency of drinking cups, pencils, food, books, and clothing. We have learned that germs grow rapidly in moist, warm places where there is food for them. When this warm, moist place is the throat or nose, it is apparent that the easiest way to scatter the germs is by coughing or by spitting. If you stand between your schoolmates and the light, you will notice that as they talk little droplets fly out of their mouths and pass into the air in a constant spray. This spray easily reaches from eighteen inches to three feet from the person who talks. It is quite evident that any one who has germs in his throat or mouth could easily pass them into the air with these

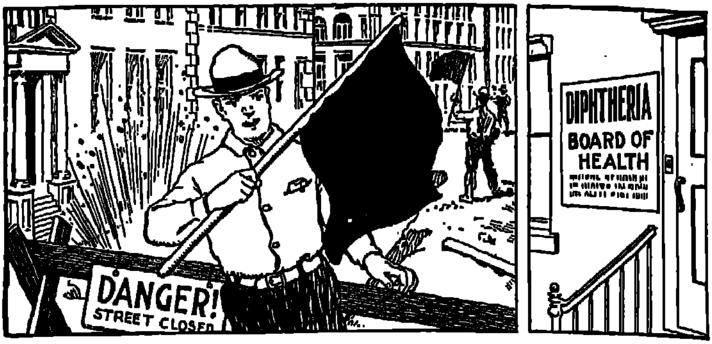


Give three practical suggestions that will lessen the dangers shown in this figure.

little droplets to someone who stood within the three-foot limit. The common cold is largely spread in this way. People having colds should be kept at home as they are able to give these colds to others very easily.

The Incubation Period of a Disease. Practically every child's disease begins with sneezing, running at the nose, and a slight cough and fever; so it is evident that if a child has any or all of these symptoms, he should be kept from school. We have learned that the period from the time that the disease germ enters and begins to grow in a person's body until the time that the symptoms of the disease are evident is called the *incubation period.* During this period of time the disease germs are growing in the body but not making themselves known because the poisons which they give off have not been formed in large enough quantities to affect the person's system seriously. This incubation period varies considerably for different diseases. For mumps, it is 15 to 22 days; for whooping cough, 8 days; for chicken pox, 11 to 22 days; for measles, 8 to 15 days; while for diphtheria, it is only from 1 to 5 days. If, after exposure to an infectious disease, the symptoms do not develop within the time of the incubation period, the exposed person has escaped the disease.

Why We Have Quarantine Regulations. You have probably all seen a blasting gang at work. You have noticed just before the blast is set off that one or two members of the gang go out into the street, waving red flags and calling out, "Fire! Fire!" You have been interested to see what happens; how the men set off the blast with electricity, how the whole mass rises into the air with perhaps a few rocks or logs flying high in the air. Then the workmen troop back to the place where they were drilling; work goes on as before and traffic on that street is again resumed. We have been protected by the



Two kinds of warnings which are intended to save lives. Are quarantine placards used in your community?

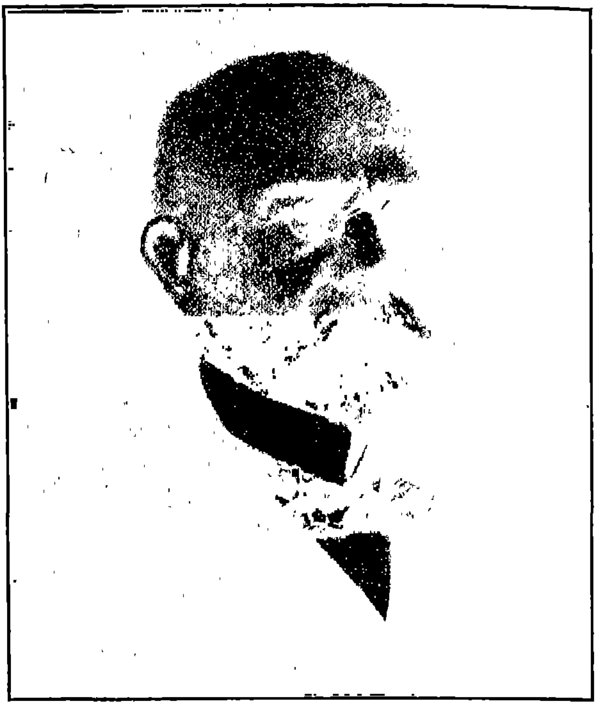
red flag of danger. Similarly by means of a red or other conspicuous placard the health department in our community warns people that there is a contagious disease in a particular house. The health officer in a community has a right to keep people in who are sick with certain contagious diseases, and to put a placard on the house, that all may know of the danger from disease there. This restriction is known as *quarantine.*

Some After-Dangers. Doubtless it seemed irksome and needless to some of you that during an attack of measles the doctor insisted not only that you should be isolated from the rest of the young people in the family, but also that you be kept in a darkened room for several days. Now, measles is not an eye disease and you may have wondered why he did this. If you had been older and wiser, you would have realized that certain germ diseases are more feared for the harm they may do the individual in later life than what they do at the time. Doctors could tell you of many cases where measles or scarlet fever have left a trail of weakened body organs which have made people semi-invalids and sent some to early graves. It pays to take care of oneself at the time when one has measles or scarlet fever.

Quarantine during the Incubation Period Important. Thus it is evident why quarantine restrictions are placed on people who are ill with catching diseases. We should do all we can to co-operate with the health authorities. We should do more than this, for if members of our family have been exposed to a germ disease, they may then have the disease in its incubation period and consequently may be more dangerous than if they actually were ill with the disease. We thus see that quarantine of the sick is not sufficient to protect us, we must quarantine any who have been *exposed* to the disease until the incubation period is passed. Do you see why this will protect people?

Reasons for Disinfection. It is often necessary to destroy bacteria as they leave the body, in order to prevent them from harming someone else. This is usually done with chemicals by a process known as *disinfection*. Some of the substances used are iodine, chloride of lime, carbolic acid, formaldehyde, mercurochrome, and bichloride of mercury. All these substances are poisonous and should be handled with great care. Where the disease exists, it is necessary to disinfect the bedclothing, handkerchiefs, and other things that the patient uses every day. Disinfection is of two kinds: *concurrent* or that which occurs from day to day, and *terminal* or the final disinfection after the disease is over. Which method do you think is the more effective? Are both kinds necessary? If so, why?

How We May Help to Fight Infectious Diseases. The first and biggest thing that any person can do to help fight infectious diseases is to be unselfish. One should observe all health rules honestly and intelligently. If an infectious disease does appear in our home, we must see to it that the case is strictly quarantined from other members of the family and that all the dishes, clothes,

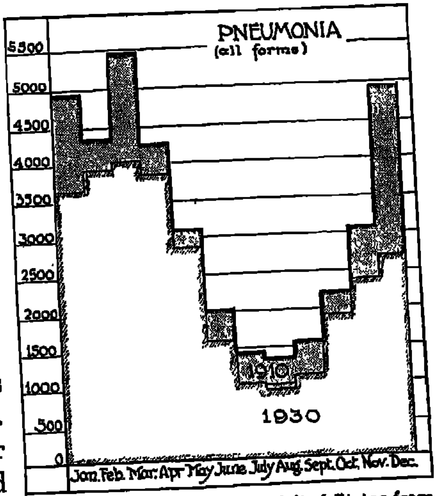


ROBERT KOCH, 1843–1910.

ON December 11, 1843, a boy was born in Klamthal, Germany, who became honored all over the world. Robert Koch was a poor boy, but early in life he showed great interest in science and stood so high in school that his father sent him to the University. Near the end of his career there, he won a prize which enabled him to go to a medical school. As a young country doctor, he was much beloved by his patients. On his 28th birthday, his wife gave him a microscope and that started him on a series of discoveries of very great benefit to mankind. People were just beginning to believe germs caused disease, and he, using these beliefs, first *proved* that a disease called anthrax was caused and transmitted by a germ. Later he discovered the germ that caused tuberculosis, and still later made a substance called tuberculin, that he believed would cure tuberculosis. It did not do this, but it gave doctors a test which tells whether or not a person has tuberculosis germs in his body. Koch died, greatly honored and beloved, in May, 1910.

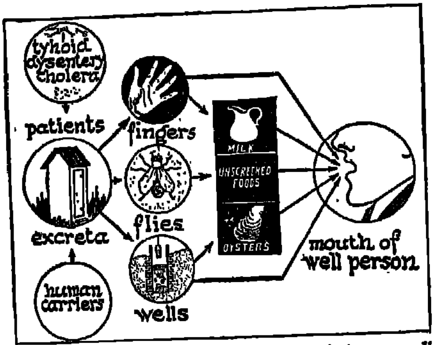
bedclothes, and everything else used by the patient are carefully disinfected.

Seasonal Variations in Disease. In some cities where the board of health keeps careful records, we find that certain diseases, such as diarrhea (dī′ă-rē′ă), are much more prevalent during the summer than during the winter. This seems to be due, in part at least, to the fact that foods do not keep as well in warm weather as in cold because warm weather aids the growth of germs. Milk, as well as other food, is easily spoiled in warm temperatures. Since milk is the food of babies, they often suffer from intestinal diseases in summer. When we remember that flies are very prevalent in the summer time, that they frequent dirty places, and that they might take up the diarrhea germs and carry them to milk, we have reason to believe that flies may be one cause for the seasonal variation in this and other diseases. Typhoid fever is another disease which is more prevalent in warm than in cold weather. It is interesting to know that in recent years deaths from these summer diseases have been much reduced largely because of our better knowledge regarding the care of babies, pasteurization of milk, and screening from flies. There are other diseases, as pneumonia, diphtheria, and scarlet fever, which are more prevalent in the winter.



Compare the deaths in the United States from pneumonia in 1910 and 1930.

Insects in Relation to Disease. If you have ever noticed flies around the house, you know that they are attracted by foods. You also will have observed that they have a very keen sense of odor. It is not pleasant to think of flies carrying germs from garbage pails and open privies to our food, but such they undoubtedly do, as is seen by reference to the diagram above. Flies, however, are not such a menace as they once were, both since we know better how to fight them and because there is less typhoid fever and other intestinal troubles than there used to be. Other insects play a part in the transmission of disease. Mosquitoes have been shown to carry yellow fever and malaria. We shall see later that other diseases of world-wide importance, such as plague, typhus, and sleeping sickness, are carried by different insects.



How may diseases be transmitted to a well person? In what way may one protect himself against them?

SELF-TESTING EXERCISE

Select from the following list of words those that best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

flies	kissing	adult's	children's
can	typhoid	mosquitoes	bone
mouth	clean	germs	contract
opening	spray	foods	animals
plants	nose	closing	cannot
filthy	insects	handle	skin
intestinal	contact	break	

Germs causing disease get into the body through a body (1)____ such as the (2)____ or (3)____ or through a (4)____ in the (5)____. Therefore, we get germ disease either by actual (6)____ with people, as in (7)____, or by putting into our (8)____ things containing germs or by taking in the germs in (9)____ (10)____ from people who have the disease. Diseases are caused by (11)____ spread in this way. Carriers are a great source of danger because we (12)____ tell who they are. Such people, who may be milkmen, waiters, or cooks, often (13)____ our (14)____. Thus they are often responsible for the spread of (15)____ and other (16)____ diseases because of their (17)____ habits. Other diseases are carried by (18)____. Such may be malaria, which is spread by (19)____, or diarrhea, which is often carried by (20)____.

PROBLEM TEST

Your small brother has measles and you have been playing with him for some days before he came down with the disease.

Check the sentences below which tell what you should do.

1. Continue to go to school as usual.
2. Gargle your throat every day.
3. Remain at home for at least two weeks.
4. Fumigate all your clothes, take a bath, and then go to school.

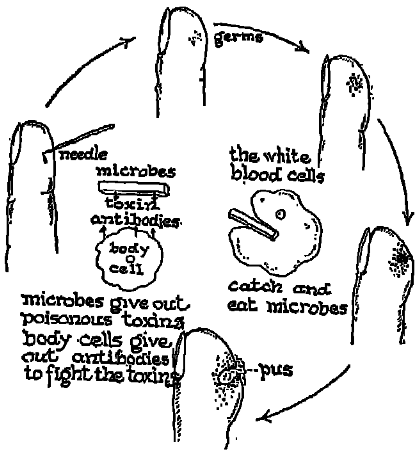
Check the sentence or sentences below which give the best reasons for your answer above.

1. If you gargle your throat, it keeps the germs from gaining entrance.
2. Measles is such a light disease that everybody ought to take it and get it over with.
3. Fumigation is the safest method of killing germs.
4. The incubation period of measles is from 8 to 14 days.

PROBLEM III. WHAT IS IMMUNITY AND HOW MAY IT BE OBTAINED?

How the Body Protects Itself from Disease Germs. We have already learned that germs get into the body through openings, such as the mouth, nose, or wounds. The skin is a protective covering. The blood contains protective cells, certain kinds of colorless corpuscles,

which feed upon such germs as may get into the body, thus acting as sanitary police. The body has developed a third defense against germs in the form of protective substances which are manufactured by certain cells to defend themselves against the *toxins* or poisons made by disease germs. These substances, called *antibodies*, are found in the blood, where they may make harmless the poisons given off by the germs, or may even destroy the germs.



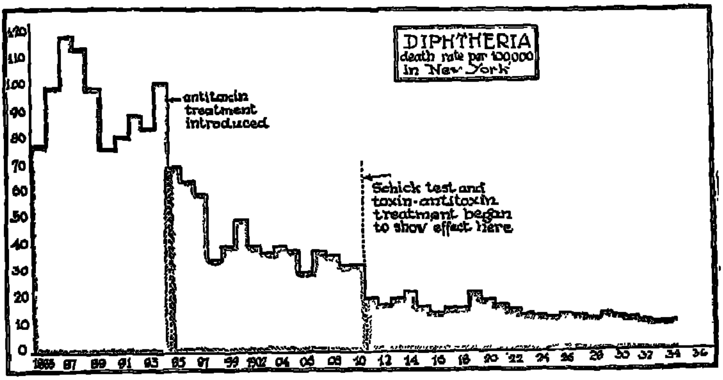
Read your text and study this diagram carefully. Then tell how the body protects itself from germs.

Immunity: Natural and Acquired. Occasionally, as we well know, someone who has been exposed to a communicable disease does not take the disease and we say he is *immune* against that disease. This may be a natural immunity, one that he has had all his life. Sufficient antibodies are "on the job" at all times and can kill any harmful germs that might enter. Some persons are more susceptible to diseases than others. This susceptibility may be caused by fatigue, overwork, or by misusing the body in any way, such as through the use of drugs or of alcohol, so that the blood is not able to resist the poisons given off by the bacteria. In such persons, antibodies are not formed rapidly enough to kill the invading germs.

It is also possible for the body to acquire temporary immunity against diseases through the use of *antitoxins* and *vaccines*. These substances are given either to

neutralize the products formed by the disease germs or to stimulate the body to produce its own antibodies. Each disease has to be fought by its own specific antitoxin or vaccine. We shall see later in our study of biology just why this is so.

Use of Antitoxin for Diphtheria. Perhaps the most widely known antitoxin is that used for the prevention of diphtheria. An antitoxin is produced in the body under the stimulation of a toxin or poison given off by germs. The antitoxin will neutralize or destroy only the toxin which caused it to come into existence. It is one form of an antibody. In the preparation of antitoxin for diphtheria, a certain amount of diphtheria toxin is introduced into the blood of young, healthy horses. This causes the horses to produce an antitoxin against diphtheria. As soon as the blood of these horses has a large amount of antitoxin, small amounts are taken from time to time to be used in the preparation of a human antitoxin.



Study the graph carefully. Compare the death rate in 1888 with the death rate in 1898. Why the difference? Why does the disease not disappear?

The serum or liquid part contains all the antitoxin, and it is put up in small tubes to be injected into the body of a person who has diphtheria.

Schick and Dick Tests. The Schick test is a method by means of which it can be determined whether a child is susceptible to diphtheria. A very small amount of diphtheria toxin is placed under the skin of the arm. If a little red spot appears a few hours later, it shows the child might contract diphtheria if he were exposed to the disease. If this is the case, the child should be given the treatment known as toxin-antitoxin for diphtheria. This consists in injecting small amounts of diphtheria toxin and antitoxin into the blood. This will cause the body to produce its own antibodies, thus building up a resistance against the disease. A somewhat similar test to determine a person's susceptibility toward scarlet fever is known as the Dick test.

Vaccination. In early colonial days in this country nearly everybody had the dreadful disease called smallpox, which often killed and always marked the patient for life with scars left by the disgusting sores of the disease. A short time after the Revolutionary War in America, Edward Jenner, an English physician, learned that many girls who were dairymaids did not contract smallpox, and he had decided that if people had the milder but similar disease of cows known as cowpox, they would not get smallpox. This was the beginning of the idea of vaccination. Dr. Jenner inoculated a number of people with the substance that causes cowpox and found that this made them immune to smallpox. Gradually the method of making the vaccine was improved so that today millions of people are vaccinated against smallpox with no harm to themselves and with the result that they are protected against smallpox. Wherever vaccination is required by law (as it is in some states and countries), smallpox is rarely found, and wherever vaccination is not required of all people, outbreaks of smallpox frequently occur.

In the case of vaccination against typhoid, dead typhoid germs are injected into the body, where their toxins cause the healthy cells to produce substances which cause the

This shows the first vaccination against smallpox by Dr. Jenner.

body to become immune for a short time. When an antitoxin is used in treating a disease, the substances *already prepared* are injected into the blood, where they neutralize the products formed by the disease germs.

For What Diseases Can We Receive Immunity? We have already seen that an antitoxin can be made to fight diphtheria. A similar method is used to fight tetanus, the dread germ causing "lockjaw." This method of receiving immunity is called "passive" immunity because the work of making the antibody takes place outside of the body. We can receive immunity by the injection of dead germs in the case of typhoid, paratyphoid, Asiatic cholera, and bubonic plague. Immunity can be given by using weakened organisms which are incapable of giving a severe attack of disease in the case of anthrax,

smallpox, and rabies or hydrophobia. This latter type of immunity which is given by dead germs or weakened organisms is called *active immunity,* because the body works against the poisons and manufactures its own antibodies, which combat the disease.

SELF-TESTING EXERCISE

Select from the following list of words those that best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

well	germicides	vaccines	disinfectants
immune	antitoxins	sick	treatment
disease	Schick	diphtheria	antibodies
take	toxin	injected	inoculation
germs	scarlet fever	kill	vaccination
give	body	Dick	mind

A person is immune to a certain (1)____ when he is exposed to the (2)____ that cause it, but does not (3)____ the disease. His (4)____ has power to (5)____ the germs, so they cannot grow there. Immunity can be obtained by use of (6)____ and (7)____. If antitoxin for diphtheria is (8)____ into the body, it will prevent (9)____. The (10)____ test will tell if you are susceptible to diphtheria and the (11)____ (12)____ treatment will keep you from having the disease, if you are susceptible. In (13)____, weakened or dead germs which cause the (14)____ are injected into the (15)____, and the blood then produces the (16)____ which fight the disease and cause the person to become (17)____.

PROBLEM TEST

During the years 1921–26 Massachusetts, with a population of 4,197,000, had 64 cases of smallpox, while in the same period California, with a population of 4,316,000, had 26,985 cases.

Check the sentence below which best explains this statement.

1. The climate of California was favorable for smallpox.
2. The numerous races living in California gave the large case rate.
3. Impure water carries smallpox organisms and thus accounts for the difference.
4. Massachusetts had better vaccination laws and enforced them; thus people were protected against smallpox.

PROBLEM IV. WHAT DISEASES DO THE MOST HARM TO CHILDREN?

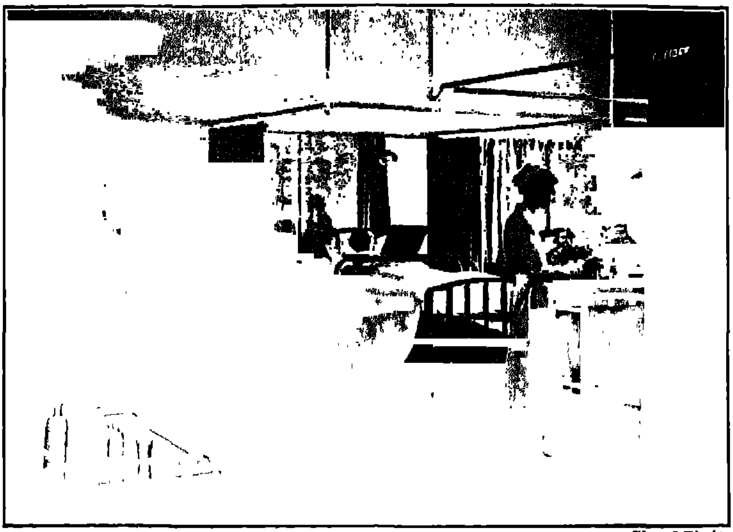
A careful study of various records and graphs shows that certain diseases kill more children between the ages of one and nine than any others. These are pneumonia, measles, tuberculosis, scarlet fever, whooping cough, and diphtheria. The disease which keeps more children away from school than any other is the common cold. We should, therefore, know something about this and other diseases, how to recognize them and how to fight them.

The Common Cold. This disease causes more absences from school and work than any other disease. There are two kinds of colds. In one kind the germ which causes the disease normally lives in the nose and throat. When a person gets overheated and then chilled, the membrane lining the nose and throat becomes irritated and the germs grow more rapidly, thus causing the symptoms of a cold. This kind of cold is thought not to be contagious. The contagious cold is probably caused by the same kind of germ, but it is more severe in its effects and can be passed on by the droplet method or by using unwashed cups, plates, spoons, or towels used by those who have a cold. Rest, not medicine, is the best way to cure a cold. Go to bed until it is over. Colds are often fought with vaccines, but we are not much beyond the experimental stage in this treatment. Colds are serious because they may render us susceptible to other diseases, such as bronchitis, pleurisy, or tuberculosis. Disinfection of a contagious cold should be concurrent and terminal.

Pneumonia. Pneumonia is caused by bacteria, and is transmitted by people who carry the germs, usually by direct contact through discharges from the nose and the throat. The incubation period is from two to three days. The disease comes on like a heavy cold, but with fever.

It is best to call the doctor immediately and follow his directions carefully. The patient should be isolated and nursed very carefully through the illness. Disinfection should be both concurrent and terminal.

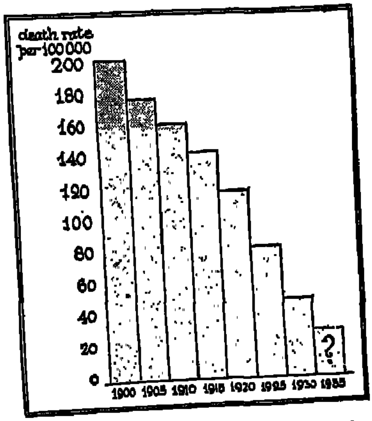
Measles. Many people consider measles a very insignificant disease, but it is in reality a serious one. Not only may children be very sick at the time, but, what is more important, they are often left with defects from which they do not recover, such as a weakened heart or defective eyes. The organism causing measles has not yet been discovered, but it is known that the secretions from the mouth and nose of a patient will cause the disease. It may be transmitted directly from person to person by the fingers, flies, or food. It is probably the most easily transmitted disease, and many children may have it in a light form without knowing it. It is most communicable during its early stage when the person having it comes



Sigurd Fischer

A hospital ward. If a person is very ill hospital care is usually better than home care because nurses are always within call.

down with what seems to be a cold in the head. The incubation period is about fourteen days. Children having the disease should be quarantined during the period when it can be given to others. The patient should be kept warm, and, especially after the rash has disappeared, should be kept from light because of the danger to the eyes. Disinfection should be concurrent and terminal.

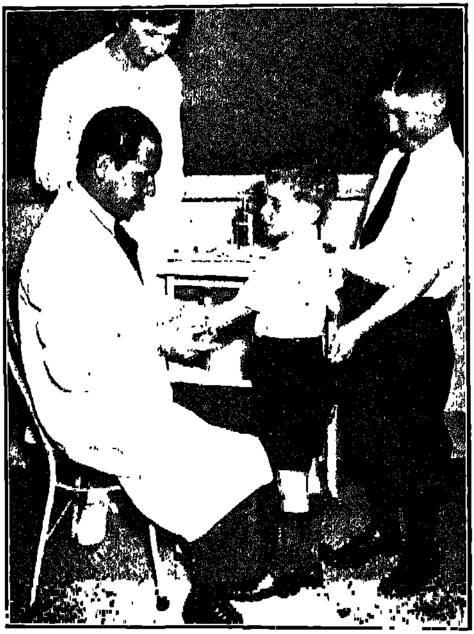


What is the probable cause of the decrease in tuberculosis?

Tuberculosis. Tuberculosis is caused by bacteria. The disease may attack almost any part of the body, although we hear more about tuberculosis of the lungs than any other kind. Tuberculosis is the one disease that has always been most dreaded by mankind. Not many years ago it was responsible for over one tenth of all human deaths, and even today it is estimated that of all the people alive in the country, probably 5,000,000 will die of tuberculosis, and yet the death rate has been more than cut in half in the past twenty-five years. It is estimated that if people who have tuberculosis would take warnings in time and really live in a hygienic way, the disease would be stamped out within the next fifty years.

Although it used to be difficult to know whether a person had tuberculosis in its early stages modern methods have made it easy to know whether anyone has the disease. A harmless test, known as the tuberculin test, is made by placing a small drop of a substance which contains a toxin formed by tuberculosis germs just inside the outer

layer of the skin. Persons who have living tuberculosis germs in their bodies react by showing a small red spot at this point. In one eastern state over 200,000 school children have been given this test. While 28 out of every 100 showed the presence of tuberculosis germs in their bodies only 1 out of every 100 were harmed enough by the germs to need continued medical care.



In many schools children take the tuberculin test as part of the regular health examination.

Tuberculosis may be easily cured if it is taken in its early stages, but it is very difficult to cure in a person who has had it for a long time. The cure is brought about by rest, plenty of nourishing food, especially milk and eggs, fresh air, and sunshine. The object is to build up the body resistance against the disease so that the body can fight the inroads of the germs.

Tuberculosis is not inherited, contrary to common belief, but it is very easily passed from one person to another in a family through carelessness in coughing or in using the same dishes and other utensils. The utmost care must be taken with tubercular patients, and they should realize the danger in which they place others. Naturally concurrent disinfection is most important.

Tuberculosis most frequently attacks workers in poorly ventilated factories and in certain occupations, such as stone cutting, street cleaning, and mining. Some people having this disease refuse to or cannot afford to rest or to pay for the care that they should have and so they get worse and many of them die. It is, therefore, better for patients to go to sanitariums if possible, as the cure can thus be effected more quickly without danger to others. Since sunshine is the enemy of germs, patients in sanitariums are placed in the open air. While in a sanitarium the patient is free from all worry, and is with people who have the same disease as he has but are cheerful and happy. He soon learns not only how to take care of himself but also to protect other people from his disease.

National Tuberculosis Association

Modern sanitariums for tuberculosis patients have wards open to the sun and air. What is the reason for this?

Scarlet Fever. Scarlet fever is caused by bacteria, recently isolated by Dr. Dick and his wife. The disease is very contagious in its early stages when the person having it appears to have only a slight cold. It is trans-

Science Service

DR. AND MRS. DICK

GEORGE FREDERICK DICK was born at Fort Wayne, Indiana, in 1881. He took his degree in medicine at Rush Medical College in 1905, and not long after was married to Miss Gladys Henry, who has been associated with him in his research since their marriage. Both Dr. and Mrs. Dick were early interested in scarlet fever, a disease which for many years had been most dreaded by parents because of its severity and aftereffects. Seventy per cent of the deaths from scarlet fever are among children under ten years of age.

In 1921 they published their first paper on scarlet fever, and since that time they have worked steadily at the McCormick Institute for Infectious Diseases in Chicago, and have made two very important contributions to the knowledge of how scarlet fever is caused and how to combat it. By the end of 1923 they had proved that the disease was caused by a streptococcus germ that destroys the red blood corpuscles. The next step was the production of a serum to be used to fight the disease. The first serum was produced by Dr. Dochez, of the Rockefeller Institute of New York, but this and other serums have not proved absolute cures for the disease. The most striking phase of Dr. and Mrs. Dick's discovery has come in the use of the toxin of the germ as a test for susceptibility to scarlet fever. A tiny drop of this toxin, if injected into the arm, will cause a red spot to appear if the child is susceptible to scarlet fever. An antitoxin is now used which is prepared from horse's blood in the same manner as the diphtheria antitoxin. It is used with considerable success to produce immunity if the child is in the first stages of the disease, but is not of much value if the disease has made a start.

mitted usually through discharges from the nose and the mouth and sometimes is carried by clothing, furniture, or in milk. The incubation period is usually three to five days. It can be transmitted from one person to another even four weeks after the beginning of the disease; therefore, quarantine should be enforced during this period. Scarlet fever can easily be recognized after the early stages by the red spots which appear under the skin, giving a general diffused redness. Disinfection should be concurrent and terminal. Scarlet fever sometimes leaves a person with defective eyes, bad heart, or deafness.

Whooping Cough. Whooping cough is caused by bacteria and is passed on from one person to another by discharges from the mouth and nose. Dogs and cats are said to take the disease and are a source of infection. The incubation period is from two to ten days. The period in which the disease can be transmitted is from two to eight weeks. During this time quarantine should be enforced. Disinfection should be both concurrent and terminal. Whooping cough is frequently followed by secondary infections.

Diphtheria. This disease is caused by bacteria and is transmitted through discharges from the nose and the mouth. Some people may carry the germs and, although apparently well, will be a source of great danger to children and adults. The disease is very infectious and the patient should be quarantined. Disinfection should be both concurrent and terminal. This disease is now being fought by testing the susceptibility of children by means of the Schick test and immunizing them with the toxin-antitoxin treatment. It is said that this treatment will practically stamp out diphtheria in the United States within the next ten years if the death rate continues to drop as it has in the last few years. The pasteurization of milk also aids in fighting this disease.

Exercise. Make a table for your workbook showing diseases prevalent in your community. Fill in the columns with information obtained from your text.

Disease	Cause	Source of Infection	How Transmitted	Incubation Period	Quarantine Period	Kinds of Disinfection	Methods of Control

SELF-TESTING EXERCISE

Select from the following list of words those which best fill the blank spaces in the sentences below and arrange them in proper numerical order. A word may be used more than once.

contact	controlled	fever	germ
toxin-antitoxin	insects	contagious	nursing
immunized	discharges	mouth	toes
bacteria	effects	throat	flies
diseases	hands	nose	spread
quarantined	scarlet	mild	

Pneumonia is caused by (1)____ and is transmitted by (2)____ from the (3)____ and the (4)____. Careful (5)____ is very essential. Measles, (6)____ (7)____, and whooping cough are serious (8)____ because of possible after (9)____. Whooping cough is caused by (10)____, which are transmitted by discharges from the (11)____ and the (12)____. It is a very (13)____ disease. Diphtheria, a disease of the (14)____, is (15)____ by personal (16)____, and is so very (17)____ that persons suspected of having it should be (18)____. Immunity is secured by the (19)____ treatment.

PROBLEM TEST

The death rate of tuberculosis is slowly decreasing in this country, but we shall never entirely conquer it because:

Check the sentence or sentences that best complete the statement above.

1. Germs are always present and cannot all be killed at a given time.

2. Our knowledge of the disease is not complete enough.
3. People will continue to drink milk and milk always contains tuberculosis germs.
4. It is impossible to educate everyone so that they will all act intelligently.
5. People are careless, and there are always some who disregard the rights of others.
6. Tuberculosis and the economic condition of the family go hand in hand.

Check below the reasons that best explain your answer or answers.

1. The germ causing tuberculosis has been known for many years.
2. There are two kinds of germs causing tuberculosis, bovine and human. The former does more harm to children, the latter to adults.
3. Statistics show that the death rate from tuberculosis closely follows the amount of income a family has.
4. Nourishing food, rest, fresh air, and freedom from worry are essential for the cure of tuberculosis.
5. We have no serum or antitoxin that is considered reliable by all physicians.
6. Germs of tuberculosis are relatively easy to kill, and only live under certain conditions.
7. Tuberculosis germs in milk may be killed by pasteurization.
8. People can be made to change their bad habits through education.

THE REVIEW SUMMARY

In preparing a summary of what you have found out in this unit, you will want to place emphasis on the big ideas which have come from the applications of the facts you have learned and the demonstrations you have seen. Doubtless you have done some additional reading which has helped you put together some of the facts into generalizations or fundamental underlying principles. For this unit some of these generalizations are:

1. Much communicable disease could be prevented through education and co-operation. Ignorance is responsible for much disease.
2. Infectious diseases are spread through mouth spray and direct contact.

3. All infectious diseases have an incubation period, which is the time when such diseases are largely passed on to others.

4. Quarantine protects against infectious diseases.

5. Insects carry diseases but do not cause them.

6. Immunity against a disease may be natural or acquired.

7. Acquired immunity may be obtained through antitoxins or vaccines.

8. The germ diseases which do most harm to children are the common cold, measles, pneumonia, scarlet fever, tuberculosis, whooping cough, and diphtheria.

Before making your review summary for your workbook, test your knowledge of the facts of the unit by checking over the text so as to be sure you know the facts underlying the science principles or generalizations. Then using this material and everything you have read, seen, or done yourself, make your summary outline. This outline you may use when you make a recitation.

TEST ON FUNDAMENTAL CONCEPTS

In a vertical column under the heading CORRECT *write numbers of all statements you believe are true. In another column under* INCORRECT *write numbers of the false statements. Your grade = right answers* $\times 2\frac{1}{2}$.

I. **Infectious diseases are spread:** (1) by using the same drinking cups, plates, etc., as people who are sick; (2) by coming within the danger zone of spray from the mouth of sick people; (3) by breathing the same air as sick people; (4) through spitting and coughing.

II. **Variations in the amount of disease at different seasons occur because:** (5) of hot and cold weather; (6) some people carry disease more readily in hot weather; (7) flies and mosquitoes carry disease germs; (8) milk is more likely to contain germs in summer than in winter.

III. **Quarantine is useful because it:** (9) keeps sick people away from well people; (10) gives sick people a vacation; (11) teaches people to be unselfish; (12) gives work to the health officer.

IV. **Disinfection is useful because it:** (13) hides germs; (14) makes people cleaner; (15) saves clothes that otherwise would have to be destroyed; (16) prevents transmission of disease.

V. **Immunity from certain diseases:** (17) is natural to everybody; (18) is made possible by antitoxins and vaccines; (19) is brought about by healthy blood; (20) is helped by keeping in good physical condition.

VI. **The Schick and Dick tests are used because:** (21) they cure disease; (22) they show if a person is immune to a certain disease; (23) they show if a person is susceptible to a certain disease; (24) doctors advise its use to prevent epidemics of scarlet fever and diphtheria.

VII. **Vaccination against smallpox:** (25) prevents smallpox; (26) protects one against smallpox for life; (27) is useless as a preventive measure; (28) protects persons against smallpox from 6 to 10 years.

VIII. **The common cold:** (29) causes more school absence than any other disease; (30) may be contagious; (31) never has any serious consequences; (32) should be fought with medicines rather than rest.

PRACTICAL PROBLEMS

1. A short time ago a very bad epidemic of septic sore throat broke out in Lee, Massachusetts, a town of about 4000 inhabitants. About 30 people died and over 600 were ill. Septic sore throat is most frequently spread through milk by people who work in dairies carrying the disease. How might the Lee epidemic have been averted?
2. John wanted to go on a camping and canoeing trip up the Merrimac River which flows through a thickly settled valley. He was told by his father that he could not go unless he took inoculations for typhoid and paratyphoid two weeks before the trip. His camp mates ridiculed the idea. Who was right, and why?
3. Certain people deny that germs cause disease. What facts could you bring forward to disprove this?
4. How would you disinfect the room of a person who had scarlet fever? Why?
5. What kind of disinfection should be practiced by a person who has tuberculosis? Why?
6. Study the various diagrams on pages 409 and 421 and state what kind of immunity is illustrated by each.
7. How are the Schick and Dick tests used? Could they be considered as protective in the same sense as an antitoxin or a vaccine?

INTERESTING THINGS TO DO, READ ABOUT, OR SEE

1. What habits should be formed to prevent taking an infectious disease? What can you do as a member of the school group to prevent the spread of such diseases? Arrange your answer in tabular form.

2. Report on the life and work of Jenner.

3. Send for the U. S. Health Service Reports and see in what parts of the country vaccination is prevalent. Do these states require vaccination? Ask the librarian to help you get bulletins and books on the subject.

4. Look up in periodicals some account of the buildings recently completed in the city of New York and which are shown on page 402. Make your report to the class.

5. Home Experiment. To Discover What Food Materials Are Most Attractive to Flies

Materials. Eight small butter dishes. The following food materials: bit of stale fish, meat, bread, milk, fresh slice of apple, slice of decaying banana, water, manure.

Method. Place a small piece of each food material on a butter dish. Place these about one foot apart where flies have ready access to them and withdraw to a distance from which you can watch results. Count the number of flies on each material at the end of 2, 4, 6, 8, and 10 minutes.

Results and Conclusions. Tabulate the results and draw conclusions.

Application. What suggestion does this give to help you explain the reason for the number of flies found in a store, in a shop, a stable or livery, or in your own back yard?

6. Home Experiment. To See the Effect of Borax or Kerosene When Used in the Breeding Places of Flies

Materials. Borax, kerosene, table waste or stale meat, empty sirup cans.

Method. Make three portions of table waste (garbage), or stale meat may be used instead. Cut the tops off the three cans. Put one portion into a can, filling it half full. Mix a second portion with a tablespoonful of borax. Put this into a second can. Put the third portion, thoroughly mixed with one or two tablespoonfuls of kerosene, into a third can. Place these three cans where flies may readily reach them. Examine them at three-day periods for several weeks, to see if maggots and flies develop.

Results and Conclusions. Tabulate the results and draw conclusions.

7. Home Experiment. To See If Oil Will Prevent Development of Mosquitoes in Water

Materials. Two pails, kerosene.

Method. Fill two pails with water. Place these out of doors close to bushes or shrubs where mosquitoes are found. Let them

remain for several weeks, examining every three days for the presence of wigglers.

Results and Conclusion. What are the results? What is the value of the oil in helping to reduce the mosquito evil?

8. Make a list of the laws in your community which have to do with infectious disease. Ask your school physician for help.

9. After visiting your local board of health, hospitals, and public markets, score your community with the card on p. 438. Does this score suggest any changes for improvement?

SCIENCE FOR LEISURE TIME

1. Make a list of superstitions held about disease by each of your classmates and get each one of them to give you evidence for this belief if they can. This can be made into a game. Have the superstitions or beliefs written on cards and distribute these cards in a group who have contributed the statements. Each member of the group must try to object to the statement on his card from a scientific point of view and must try to bring evidence against it. After he has finished, the person who made the statement has an opportunity to reply. The group will vote on the evidence for or against the statement.

2. Can you grow snakes from horse hairs? Place several horse hairs in a bottle with pond or tap water. Cork the bottle and put aside for some days in a warm place. What happens?

SCIENCE CLUB ACTIVITIES

1. Make a trip to your local board of health to find out what tests and what immunity protection is given free in your community.

2. Make a group survey of your community. Find out where the areas are in which flies or mosquitoes breed, and then organize a campaign to exterminate these pests.

3. Work up a chart as a group project to be used in the classroom which shows in form of a talk just what you would do to protect yourself against the following diseases: malaria, scarlet fever, colds, diphtheria, typhoid, measles, tuberculosis.

4. Have a club meeting devoted to the question of what are the advantages of living in the country as compared with living in the city.

5. Study the summaries of diseases in the reports of your state department of health and make chart graphs showing the seasonal variations of one of the following diseases: measles, pneumonia, scarlet fever, typhoid, malaria, diphtheria, smallpox, or influenza.

SCORE CARD. WORK OF THE BOARD OF HEALTH

		Perfect Score	My Score
EQUIPMENT AND PERSONNEL	Board of health active and free from politics (5) Equipment good (5), fair (3), poor (1) Physicians employed give entire time to work (5), part time (1)	15	
QUARANTINE AND SERUMS	Quarantine laws strictly enforced (5), partly (2) Contagious diseases reported by school physicians (5), not reported (0) Disinfection required by law and law always enforced (5), sometimes (1) *Free antitoxins and vaccines (5), not free but* obtainable at all times (4), not obtainable (0)	20	
HOSPITALS AND RESEARCH	Hospitals ample for community needs (5) It has various types of hospitals or special departments General (4) Eye, ear, nose, throat (4) Surgical cases (2) Maternity (2) Contagious diseases (2) Tuberculosis hospital or sanitariums (4) Division of research formed (1) *Bureau of vital statistics (1)*	25	
CO-OPERATION AND LAW ENFORCEMENT	Private institutions co-operate with board of health. Co-operation with board of health on part of school children (5), parents (5) Law enforcement on spitting (5) Laws other than Interstate Commerce Act on killing and sale of meats, with enforcement of such laws (5) Supervision of food supplies (5) Law enforcement on manure heaps and outdoor privies. Campaigns of health education started (3) Co-operation with state and public health service (2) Co-operation with civic associations in health or clean-up campaign (10)	40	
	TOTAL	100	

6. Have the club make a visit to the city health department, get all the information they can, and then rate its efficiency, using the score card on page 438.

7. Visit a laboratory where antitoxins are made and have different members of the club prepare papers to be read in class on "Ways in which vaccines are made and used."

REFERENCE READING

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GLOSSARY

The diacritical marks are those used in the Webster School Dictionaries.

accumulate (ă-kū'mū-lāt): To bring together.
addict (ă-dĭkt'): One who uses drugs, etc. habitually.
Adirondack (ăd'ĭ-rŏn'dăk): Mountains in New York State.
adulteration (ă-dŭl'tẽr-ā'shŭn): The state of being made of a lower grade by the addition of a foreign or cheaper substance.
Aëdes (ā-e'dēs): The mosquito that carries yellow fever.
algae (ăl'jē) (Plu. of ăl'gă): A chlorophyl containing plant of the class Thallophytis. Especially seaweeds.
anaerobic (ăn-ā'ẽr-ŏ'bĭk): Bacteria capable of living without free oxygen.
analogy (ă-năl'ō-jĭ): Similarity of relations.
Anopheles (ă-nŏf'ĕ-lēz): A genus of mosquitoes whose bite is the usual means of infecting human beings with malaria.
antibody (ăn'tĭ-bŏd'ĭ): Substances in the blood which fight harmful bacteria or toxins.
antiseptic (ăn'tĭ-sĕp'tĭk): A substance that prevents the growth of harmful microörganisms.
antitoxin (ăn'tĭ-tŏk'sĭn): A substance produced in the body of an animal and used to overcome the effects of disease-producing bacteria.
aquatic (ă-kwăt'ĭk): Living in water.
aqueduct (ăk'wē-dŭkt): An artificial channel or conduit for carrying water.
Archimedes (är'kĭ-mē'dēz): A Greek scientist and mathematician.
artesian (är-tē'zhăn): A deep bored well.
artesian well: A well made by boring until water is reached, which, from internal pressure, flows spontaneously.
auditorium (ô'dĭ-tō'rĭ-ŭm): That part of a building assigned to the audience.
bacteria (băk-tē'rĭ-ă): A group of microscopic organisms.
bubonic (bū-bŏn'ĭk): Relates to disease attended by swelling of lymphatic glands.
calculation (kăl'kū-lā'shŭn): Reckoning.
carrier (kăr'ĭ-ẽr): A person capable of transferring disease germs. A high frequency wave used in radio transmission.
cavity (kăv'ĭ-tĭ): A hollow place.
cell (sĕl): A small structural unit of which plants and animals are composed.
centipedes (sĕn'tĭ-pēdz): Small wormlike animals with numerous body segments each with a pair of legs.
chlorinate (klō'rĭ-nāt): To treat with chlorine.
chromium (krō'mĭ-ŭm): A grayish white hard metal.
cilia (sĭl'ĭ-ȧ): Threads of protoplasm lining the surfaces of cells.
circuit (sûr'kĭt): The complete path of an electric current.
clepsydra (klĕp'sĭ-dră): A water clock.
commission (kŏ-mĭsh'ŭn): A body of persons to perform some duty.
compressed (kŏm-prĕst'): Pressed together.
concentrated (kŏn'sĕn-trāt'ĕd): Very strong.
consequently (kŏn'sē-kwĕnt-lĭ): By natural sequence.
conserve (kŏn-sûrv'): To save.
contagious (kŏn-tā'jŭs): Catching.
contaminated (kŏn-tăm'ĭ-nāt'ĕd): Polluted or made impure.
continental (kŏn'tĭ-nĕn'tăl): Pertaining to a continent.
convection (kŏn-vĕk'shŭn): A process of transferring heat by a current of liquid or gas.

counteract (koun'tĕr-ăkt'): To act in opposition.
criminally (krĭm'ĭ-năl-ĭ): Wickedly or contrary to law.
culture (kŭl'tūr): Act of improving.
deficient (dē-fĭsh'ĕnt): Lacking.
deflecting (dē-flĕkt'ĭng): Bending.
depression (dē-prĕsh'ŭn): A lowering or sinking.
diaphragm (dī'ă-frăm): A vibrating disk as in the telephone. Muscular partition separating the chest cavity from the abdomen.
efficiency (ĕ-fĭsh'ĕn-sĭ): The percentage found by dividing the amount of work obtained from a machine by the total work put into it.
elastic (ē-lăs'tĭk): Capable of recovering size and shape after distortion.
equilibrium (ē'kwĭ-lĭb'rĭ-ŭm): A state of balance.
eradicate (ē-răd'ĭ-kāt): To destroy.
erode (ē-rōd'): To eat away.
erosion (ē-rō'zhŭn): Act of wearing away.
eruption (ē-rŭp'shŭn): Act of bursting forth.
eventually (ē-vĕn'tū-ăl-ĭ): Finally.
excess (ĕk-sĕs'): Going beyond limits.
exhale (ĕks-hāl'): To breathe out.
extermination (ĕks-tûr'mĭ-nā'shŭn): Total destruction.
extinguish (ĕks-tĭɴ'gwĭsh): To put out.
fissure (fĭsh'ūr): A narrow opening made by the parting of a substance.
fluorescent (flōō'ō-rĕs'ĕnt): Emitting light when exposed to certain invisible rays.
glazed (glāzd): Having a glassy surface.
Greenwich (grĭn'ĭj): The observatory in England through which the 0° meridian passes.
humidifying (hū-mĭd'ĭ-fī'ĭng): Moistening.
humidity (hū-mĭd'ĭ-tĭ): Water vapor in the air.
humus (hū'mŭs): Soil produced from the decay of animals and plants.
ignite (ĭg-nīt'): To take fire.
illuminate (ĭ-lū'mĭ-nāt): To light up.
impervious (ĭm-pûr'vĭ-ŭs): Not admitting passage through.
incandescent (ĭn'kăn-dĕs'ĕnt): White hot or glowing with heat.
incinerator (ĭn-sĭn'ĕr-ā'tĕr): A furnace for burning substances.
incubate (ĭn'kū-bāt): To maintain a temperature favorable for eggs to hatch.
inertia (ĭn-ûr'shĭ-ă): Tendency of a body to remain in its state of rest or motion unless acted upon by some outside force.
inoculation (ĭn-ŏk'ū-lā'shŭn): Introducing a serum into a person to prevent or cure a disease.
instantaneous (ĭn'stăn-tā'nē-ŭs): Done at once.
incubation period (ĭn'kū-bā'shŭn): Time between when germs causing disease are taken into the body and when symptoms of disease are noticed.
infra-red (ĭn'fră-rĕd): That part of the spectrum lying outside the visible spectrum near the red end.
insulated (ĭn'sū-lāt'ĕd): Separated by non-conducting material.
insulator (ĭn'sū-lā'tĕr): A body through which an electric current passes slightly if at all. A body through which heat passes with difficulty.
intensities (ĭn-tĕn'sĭ-tĭz): Magnitude; brilliance.
interdependence (ĭn'tĕr-dē-pĕn'dĕns): Mutual dependence.
international (ĭn'tĕr-năsh'ŭn-ăl): Between nations.
inverse (ĭn-vûrs'): Opposite in nature. Reverse.
invertebrate (ĭn-vûr'tē-brāt): An animal having no backbone or spinal column.
irrigation (ĭr'ĭ-gā'shŭn): To water land for agricultural purposes by means of canals or ditches.
laboratory (lăb'ō-ră-tō-rĭ): A chemist's work room.
lacquer (lăk'ĕr): A kind of varnish or shellac.
larvae (lär'vē): The immature often wormlike form of insects.
liana (lē-ä'nă): A climbing vine of the tropics.

mammal (măm′ăl): Every animal that nourishes its young with milk.
meridian (mē-rĭd′ĭ-ăn): A great circle on the earth's surface passing through the poles.
mica (mī′kȧ): A mineral that crystallizes in thin sheets which are often transparent.
microscopic (mī′krō-skŏp′ĭk): Too small to be seen without a microscope.
miscellaneous (mĭs′ĕ-lā′nē-ŭs): Consisting of several different kinds.
mucous membrane (mū′kŭs mĕm′-brān): Lining of any body cavity.
nodules (nŏd′ūls): Thickened knots or lumps on roots of legumes.
Oersted (ûr′stĕth): A Danish scientist who discovered the relationship between electricity and magnetism.
parapet (păr′ȧ-pĕt): A barrier or wall.
parasitic (păr′ȧ-sĭt′ĭk): Living on other organisms.
pendulum (pĕn′dū-lŭm): A body suspended so as to swing freely.
pestilence (pĕs′tĭ-lĕns): An infectious epidemic disease that is virulent.
phosphorescence (fŏs′fŏr-ĕs′ĕns): State of giving light without sensible heat.
phosphorescent (fŏs′fŏr-ĕs′ĕnt): Luminous without sensible heat.
plague (plāg): An infectious disease.
plastic (plăs′tĭk): Capable of being molded.
plateau (plȧ-tō′): A table land.
pneumatic (nū-măt′ĭk): Worked by air pressure.
polluted (pŏ-lūt′ĕd): Unclean.
polyp (pŏl′ĭp): A small water animal, as hydras and corals.
posture (pŏs′tūr): Attitude; pose; the position or bearing of the body as a whole.
potassium (pō-tăs′ĭ-ŭm): A soft silver-white metal.
predisposed (prē′dĭs-pōzd′): Disposed or inclined beforehand.
preservative (prē-zûr′vȧ-tĭv): A substance having power to keep fruits from decaying. Also vegetables.
preventable (prē-vĕn′tȧ-b'l): Able to keep from happening.
quarantine (kwŏr′ăn-tēn): Restrictions on a sick person or one suspected of being infected with a disease.
radiated (rā′dĭ-āt′ĕd): Sent out rays as heat or light.
radiation (rā′dĭ-ā′shŭn): Act of emitting rays.
reflection (rē-flĕk′shŭn): Act of bending or turning back.
refraction (rē-frăk′shŭn): The deflection from a straight line of a beam of light in passing obliquely from one medium into another.
reservation (rĕz′ĕr-vā′shŭn): A tract of public land.
reservoir (rĕz′ĕr-vwôr): A place where water is stored.
reptile (rĕp′tĭl): Animal moving on belly or by means of short legs.
resistance (rē-zĭs′tăns): The opposition offered by a body to the passing of an electric current.
respiratory (rē-spīr′ȧ-tō-rĭ): Relating to respiration or breathing.
respiratory diseases: Diseases of the breathing organs.
rotation (rō-tā′shŭn): Act of turning on an axis.
sanitarium (săn′ĭ-târ′ĭ-ŭm): A health resort.
sanitation (săn′ĭ-tā′shŭn): Use of hygienic measures.
saturate (săt′ū-rāt): Anything is saturated when it has taken as much of the substance as possible, as when water is saturated with salt.
scorpion (skôr′pĭ-ŭn): A small animal having a venomous sting.
sediment (sĕd′ĭ-mĕnt): Material which settles in quiet water.
sedimentation (sĕd′ĭ-mĕn-tā′shŭn): Act of depositing sediment.
septic (sĕp′tĭk): Produced by putrefaction.
sewage (sū′āj): Waste matter which flows from toilets and from streets through pipes.
sidereal (sī-dē′rē-ăl): Relating to the stars.
solar (sō′lȧr): Pertaining to the sun.
solidify (sō-lĭd′ĭ-fī): To make solid.
specialized (spĕsh′ăl-īzd): Fitted for use along a special line.

species (spē'shēz): A group in the classification of animals or plants.
sterile (stĕr'ĭl): Free from microorganisms or germs.
stimulated (stĭm'ū-lāt'ĕd): Aroused or excited.
symbiosis (sĭm'bĭ-ō'sĭs): Living together for mutual benefit.
tabulated (tăb'ū-lāt'ĕd): Arranged in form of a table.
tentative (tĕn'tȧ-tĭv): On trial.
thermostat (thûr'mō-stăt): Automatic heat-regulating device.
tolerance (tŏl'ĕr-ăns): Capability of enduring or resisting the action of drugs, etc.
toxin (tŏk'sĭn): A poisonous substance produced by disease-producing bacteria during their growth.
transformed (trăns-fôrmed'): Form changed.
tubercule (tū'bĕr-kūl): Any small knotlike prominence, especially in some part of a plant or animal.
tungsten (tŭng'stĕn): A hard gray metal used for electric-light filaments.
turbine (tûr'bĭn): A special type of water wheel.
ultra-violet (ŭl'trȧ-vī'ō-lĕt): Beyond the visible spectrum at the violet end.
vaccine (văk'sĭn): Any substance used in vaccination.
ventilation (vĕn'tĭ-lā'shŭn): Process of providing a free circulation of air.
vermin (vûr'mĭn): Disgusting animals difficult to control, as fleas and rats.
vertebrate (vûr'tē-brāt): An animal having a backbone.
vibration (vī-brā'shŭn): Act of moving rapidly to and fro.
welding (wĕld'ĭng): Uniting.
Yangtse (yäng'tsĕ): River in China.

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Bold-face numbers refer to illustrations